NO. 22-2288

IN THE UNITED STATES COURT OF APPEALS
FOR THE FEDERAL CIRCUIT

APPLE INC.,
***Appellant*,**

v.

COREPHOTONICS, LTD.,
Appellee.

OPENING BRIEF OF APPELLANT APPLE INC.

Appeal from the United States Patent and Trademark Office,
Patent Trial and Appeal Board in No. IPR2020-00489

HAYNES AND BOONE, LLP

Debra J. McComas
Andrew S. Ehmke
2323 Victory Avenue
Suite 700
Dallas, Texas 75219
Phone: (214) 651-5375
Fax: (214) 200-0525

David W. O'Brien
Hong Shi
600 Congress Avenue
Suite 1300
Austin, Texas 78701
Phone: (512) 867-8457
Fax: (512) 867-8613

Angela M. Oliver
800 17th Street NW
Suite 500
Washington, D.C. 20006
Phone: (202) 654-4552
Fax: (202) 654-4252

Attorneys for Appellant Apple Inc.

RELEVANT CLAIMS OF U.S. PATENT NO. 10,015,408

5. A zoom digital camera comprising:

a) a first imaging section that includes a fixed focal length first lens with a first field of view (FOV_1) and a first image sensor; and

b) a second imaging section that includes a fixed focal length second lens with a second FOV (FOV2) that is narrower than FOV, and a second image sensor, wherein the second lens includes five lens elements along an optical axis starting from an object starting with a first lens element with positive power, wherein the five lens elements further include a second lens element with negative power, a fourth lens element with negative power and a fifth lens element, wherein a largest distance between consecutive lens elements along the optical axis is a distance between the fourth lens element and the fifth lens element, and wherein a ratio of a total track length (TTL) to effective focal length (EFL) of the second lens is smaller than 1.

6. The zoom digital camera of claim 5, further comprising a camera controller operatively coupled to the first and second imaging sections, the camera controller configured to provide video output images with a smooth transition when switching between a lower zoom factor (ZF) value and a higher ZF value or vice versa.

(Appx84)

CERTIFICATE OF INTEREST

Case Number 22-2288

Short Case Caption Apple Inc. v. Corephotonics, Ltd.

Filing Party/Entity Apple Inc. / Appellant

Instructions: Complete each section of the form. In answering items 2 and 3, be specific as to which represented entities the answers apply; lack of specificity may result in non-compliance. **Please enter only one item per box; attach additional pages as needed and check the relevant box**. Counsel must immediately file an amended Certificate of Interest if information changes. Fed. Cir. R. 47.4(b).

I certify the following information and any attached sheets are accurate and complete to the best of my knowledge.

Date: April 21, 2023

Signature: */s/ Debra J. McComas*

Name: Debra J. McComas

1. Represented Entities. Fed. Cir. R. 47.4(a)(1).	**2. Real Party in Interest.** Fed. Cir. R. 47.4(a)(2).	**3. Parent Corporations and Stockholders.** Fed. Cir. R. 47.4(a)(3).
Provide the full names of all entities represented by undersigned counsel in this case.	Provide the full names of all real parties in interest for the entities. Do not list the real parties if they are the same as the entities.	Provide the full names of all parent corporations for the entities and all publicly held companies that own 10% or more stock in the entities.
___ None/Not Applicable	X None/Not Applicable	X None/Not Applicable
Apple Inc.		

4. Legal Representatives. List all law firms, partners, and associates that (a) appeared for the entities in the originating court or agency or (b) are expected to appear in this court for the entities. Do not include those who have already entered an appearance in this court. Fed. Cir. R. 47.4(a)(4).

__ None/Not Applicable __ Additional pages attached

Jordan Maucotel (Haynes and Boone, LLP)	Stephanie N. Sivinski (Haynes and Boone, LLP)	Michael S. Parsons (formerly Haynes and Boone, LLP)

5. Related Cases. Provide the case titles and numbers of any case known to be pending in this court or any other court or agency that will directly affect or be directly affected by this court's decision in the pending appeal. Do not include the originating case number(s) for this case. Fed. Cir. R. 47.4(a)(5). See also Fed. Cir. R. 47.5(b).

__ None/Not Applicable __ Additional pages attached

Corephotonics, Ltd. v. Apple Inc., 5:19-cv-04809 (N.D. Cal.)		

6. Organizational Victims and Bankruptcy Cases. Provide any information required under Fed. R. App. P. 26.1(b) (organizational victims in criminal cases) and 26.1(c) (bankruptcy case debtors and trustees). Fed. Cir. R. 47.4(a)(6).

X None/Not Applicable __ Additional pages attached

TABLE OF CONTENTS

RELEVANT CLAIMS OF U.S. PATENT NO. 10,015,408 i

CERTIFICATE OF INTEREST ii

TABLE OF AUTHORITIES vii

STATEMENT OF RELATED CASES 1

JURISDICTIONAL STATEMENT 2

STATEMENT OF THE ISSUES 3

INTRODUCTION 4

STATEMENT OF THE CASE 7

A. Multi-lens (also multi-aperture) systems for achieving a zoom effect were known by the time of the ’408 patent. 7

B. The ’408 patent discloses a dual-aperture (dual-lens) zoom digital camera. 9

C. Golan and Kawamura each use fixed-focal length lenses to achieve a common goal of providing compact imaging systems with good image quality, as compared to imaging systems using traditional optical lenses. 15

1. Golan discloses a video output with a continuous electronic zoom for an image acquisition system including multiple imaging devices having different fixed fields of view. 15

2. Kawamura discloses a compact telephoto lens with a five-lens configuration like that disclosed in the challenged claims. 18

D. Procedural History 21

1. Apple’s IPR Petition 21

2. Apple demonstrated multiple reasons to use Kawamura's compact telephoto lens with Golan's techniques for providing a compact digital zoom camera. 22

3. Corephotonics' Patent Owner Response 24

4. Apple's Reply 25

5. Corephotonics admits in its Sur-reply and during the oral hearing that "Golan could be used in any system, miniature or otherwise." 26

6. The Final Written Decision and Rehearing Denial 29

SUMMARY OF THE ARGUMENT 30

STANDARD OF REVIEW 33

ARGUMENT 35

I. The Board erred both factually and legally by determining that there was insufficient evidence to show that Golan's teachings could be applied to larger camera lenses, such as Kawamura's lens. 36

A. Factually, the Board erred by ignoring the parties' shared understanding that Golan could be applied to camera systems of any size. 36

B. The Board improperly obligated Apple to prove Golan does not "teach away" from larger-scale imaging systems like Kawamura. 42

C. The Board's incorrect understanding regarding Golan's applicability to larger systems also tainted the Board's analysis regarding Apple's scaling evidence. 44

II. The Board compounded its errors by extending the presumption that Golan could not be used in larger camera systems to find a dispositive difference in size between Golan and Kawamura,

misunderstanding the evidence and improperly requiring bodily incorporation of one prior art reference into another....................................50

III. The Board failed adequately to address Apple's grounds supporting the combination of Golan and Kawamura................................. 60

CONCLUSION..67

CERTIFICATE OF COMPLIANCE...69

ADDENDUM..70

TABLE OF AUTHORITIES

Page(s)

Cases

Adapt Pharma Operations Ltd. v. Teva Pharms. USA, Inc.,
25 F.4th 1354 (Fed. Cir. 2022) 60, 63

Arendi S.A.R.L. v. Apple Inc.,
832 F.3d 1355 (Fed. Cir. 2016) 33

Bayer Pharma AG v. Watson Labs, Inc.,
874 F.3d 1316 (Fed. Cir. 2017) 61

Donner Tech., LLC v. Pro Stage Gear, LLC,
979 F.3d 1353 (Fed. Cir. 2020) 66

ESIP Series 2, LLC v. Puzhen Life USA, LLC,
958 F.3d 1378 (Fed. Cir. 2020) 34

In re Fulton,
391 F.3d 1195 (Fed. Cir. 2004) 61

In re Gartside,
203 F.3d 1305 (Fed. Cir. 2000) 34

Gen. Elec. Co. v. Raytheon Techs. Corp.,
983 F.3d 1334 (Fed. Cir. 2020) 43, 44, 67

Graham v. John Deere Co.,
383 U.S. 1 (1966) 34

Intel Corp. v. Qualcomm Inc.,
21 F.4th 784 (Fed. Cir. 2021) 48, 58

KSR Int'l Co. v. Teleflex Inc.,
550 U.S. 398 (2007) 34, 61

Medichem, S.A. v. Rolabo, S.L.,
437 F.3d 1157 (Fed. Cir. 2006) 60

In re Mouttet,
686 F.3d 1322 (Fed. Cir. 2012) 45, 51

In re Nievelt,
482 F.2d 965 (CCPA 1973) 51

Panduit Corp. v. Dennison Mfg. Co.,
810 F.2d 1561 (Fed. Cir. 1987) 34

PAR Pharm., Inc. v. TWI Pharms., Inc.,
773 F.3d 1186 (Fed. Cir. 2014) 61

Personal Web Techs., LLC v. Apple Inc.,
848 F.3d 987 (Fed. Cir. 2017) 33

Plantronics, Inc. v. Aliph, Inc.,
724 F.3d 1343 (Fed. Cir. 2013) 61

Princeton Vanguard, LLC v. Frito-Lay N. Am., Inc.,
786 F.3d 960 (Fed. Cir. 2015) 66

SIPCO, LLC v. Emerson Elec. Co.,
980 F.3d 865 (Fed. Cir. 2020) 34

In re Sneed,
710 F.2d 1544 (Fed. Cir. 1983) 32, 51

TQ Delta, LLC v. CISCO Sys., Inc.,
942 F.3d 1352 (Fed. Cir. 2019) 57

Tyco Healthcare Grp. LP v. Ethicon Endo-Surgery, Inc.,
774 F.3d 968 (Fed. Cir. 2014) 43

VidStream LLC v. Twitter, Inc.,
981 F.3d 1060 (Fed. Cir. 2020) 59

Statutes

28 U.S.C. § 1295 2

35 U.S.C. § 142 2

35 U.S.C. § 311 2

35 U.S.C. § 312 2

Other Authorities

37 C.F.R. § 42.104 2

37 C.F.R. § 90.3 2

Joshua L. Sohn, *Re-Thinking the "Motivation-to-Combine" in Patent Law*, 48 AIPLA Q.J. 1 (2020) 34

STATEMENT OF RELATED CASES

No appeal in or from the same proceeding was previously before this Court or any other appellate court.

Counsel is aware that the following case may directly affect or be directly affected by this Court's decision in the pending appeal:

Corephotonics, Ltd. v. Apple Inc., No. 3:19-cv-04809-JD (N.D. Cal.).

JURISDICTIONAL STATEMENT

Apple petitioned for *inter partes* review of claims 5 and 6 of U.S. Patent No. 10,015,408 ("the '408 patent"). *See* Appx163–226 (Petition), 35 U.S.C. §§ 311, 312, 37 C.F.R. § 42.104. The Board instituted review. Appx269 (Institution Decision). On July 26, 2021, the Board issued a Final Written Decision, in which it ordered claims 5 and 6 of the '408 patent not unpatentable. Appx40. Apple timely filed a request for rehearing which was denied on July 27, 2022. Appx43. Apple timely filed its notice of appeal on September 26, 2022. Appx808–812, 35 U.S.C. § 142, 37 C.F.R. § 90.3(a)(1), Fed. Cir. R. 15(a)(1). This Court has jurisdiction over this appeal pursuant to 28 U.S.C. § 1295(a)(4)(A).

STATEMENT OF THE ISSUES

The Board concluded that Apple failed to prove claims 5 and 6 of the '408 patent unpatentable as obvious despite evidence that Golan and Kawamura (a) teach each limitation of the challenged claims, (b) are analogous art in the same field of endeavor, (c) share a common objective of making compact imaging systems with good imaging quality, and (d) would have been easily and readily combined to achieve a predictable result.

1. Did the Board err in finding Apple failed to show a motivation to combine Golan and Kawamura?

2. Did the Board err in finding that Golan's teachings do not reach beyond miniature cameras and could not, therefore, render obvious a combination that included larger-scale devices?

3. Did the Board err by failing to consider Apple's other stated reasons for combining Golan and Kawamura?

INTRODUCTION

This appeal comes from a Final Written Decision in an *inter partes* review in which the Board found Apple failed to show claims 5 and 6 of U.S. Patent No. 10,015,408 ("the '408 patent") unpatentable as obvious. The Board's decision was based on an erroneous finding that a person of ordinary skill in the art would not have been motivated to combine the prior art references (Golan and Kawamura). The Board erred in at least three critical ways. First, the Board erred by limiting Golan's teachings to a camera with miniature lenses. Indeed, Corephotonics itself acknowledged that "Golan could be used in *any system, miniature or otherwise,* where the optical zoom is not available." Appx632, 22:4–11 (emphasis added). This alone shows the Board committed an error in narrowing Golan's teachings in order to argue against a combination. And that error compounded itself, ultimately leading the Board to improperly focus on whether the references could be physically combined. Second, the Board erred by seemingly requiring Apple to prove that Golan did not teach away from a limitation it did not have (namely, being limited to miniature systems). And third, the Board erred by failing to analyze Apple's other articulated reasons why a POSITA would have combined Golan and Kawamura.

Apple presented multiple reasons, which the Board erred in not applying, why a POSITA would have combined Golan and Kawamura. The primary motivating

factor emphasized by Apple was straightforward and irrefutable: both references shared a similar goal of providing compact imaging systems with good imaging quality, as compared to traditional optical lenses, which were known to be heavy and expensive. Kawamura purported to address that goal through specific optical properties that allowed it to produce a telephoto lens that was more compact (*i.e.*, smaller and therefore lighter) than a traditional optical lens of comparable focal length. Meanwhile, Golan purported to address that goal through the use of multiple fixed-focal-length lenses (one wide lens and one telephoto lens, together being much smaller and lighter than a traditional variable focal length optical zoom lens of comparable zoom range) and methods of "lossless" electronic zoom. Apple's proposed combination simply applied the complementary teaching from Kawamura of the efficient telephoto lens to Golan's teaching of the telephoto lens in the multi-lens system.

Notwithstanding the harmonious articulated goals of Kawamura and Golan, which should have been adequate on their face to show a motivation to combine, the Board rejected the combination by effectively finding that the prior art somehow taught away from the combination. In so doing, the Board made multiple errors, the most fundamental of which was finding that Golan's techniques would have been used in *miniature* cameras (*e.g.*, cell phone cameras), but *not* in the context of larger

cameras with larger lenses, such as Kawamura. That finding was entirely unsupported by the disclosure in Golan—and was contradicted by Corephotonics' own statements to the Board. That alone justifies reversal and remand, especially given the impact of that fundamental error on the remainder of the Board's analysis.

The Board's errors did not stop with its misreading of Golan's reach. Rather, clinging to the erroneous presumption that Golan's teachings did not extend beyond miniature camera systems, the Board effectively required Apple to prove a negative, *i.e.*, why Golan would *not* teach away from the proposed combination with Kawamura. The Board then used that same erroneous finding (regarding the limited scope of Golan's applicability) to conclude that Kawamura could not satisfy Golan's goals of providing a relatively "light weight electronic zoom." But, when read in context, Golan's focus on "light weight electronic zoom" using multiple, and much smaller, fixed focal length lenses was in comparison to traditional *optical zoom* lenses—and the record evidence was one-sided that Kawamura (and the combination of Golan and Kawamura) would have been considered "light weight" compared to a traditional optical zoom lens offering a comparable and mechanically variable range of focal lengths.

Further, firmly convinced in its unsupported limitation of Golan's teachings, the Board failed to properly consider Apple's other stated reasons for combining

Golan and Kawamura. For that additional reason, the Board's decision should at least be remanded for further consideration of the inadequately addressed grounds.

STATEMENT OF THE CASE

This appeal comes to the Court from a Final Written Decision in which the Board found Apple failed to show claims 5 and 6 ("the challenged claims") of the '408 patent unpatentable as obvious. The Board's decision was based solely on its determination that Apple had not demonstrated a sufficient reason to combine the two references in its obviousness combination.

A. Multi-lens (also multi-aperture) systems for achieving a zoom effect were known by the time of the '408 patent.

By the time of the '408 patent (which has an earliest possible priority date of 2013), a characteristic of many higher-performance cameras, such as standalone digital still cameras, was the ability to "vary the focal length of the camera to increase and decrease the magnification of the image." Appx78 ('408 patent), 1:35–39. This ability to provide different magnifications of the same scene or object by changing the focal length of an optical system was (and still is) referred to as "zoom" and was usually accomplished with a "zoom lens." *See* Appx78, 1:39–45.

Traditionally, zoom capability was provided using mechanical optical zooming. Appx3229, ¶ 28 (Moore Decl.) (cited at Appx32–33). Typically, "optical" zoom was performed by mechanically moving lens elements relative to each other

within a zoom lens. Appx78, 1:45–47, Appx3229, ¶ 28. Such zoom lenses were "typically more expensive, larger and less reliable than fixed focal length lenses." Appx78, 1:47–49; *see also* Appx3229, ¶ 28.

An alternative approach used to "approximat[e] the zoom effect" was through "digital zooming." Appx78, 1:49–51; *see also* Appx3229, ¶ 29 (cited at Appx32–33). Rather than changing the focal length of the lens (as in optical zooming), in digital zooming, "a processor in the camera crops the image and interpolates between the pixels of the captured image to create a magnified but lower-resolution image." Appx78, 1:51–54, Appx3229, ¶ 29.

The effect of a zoom lens could also be obtained through use of "multi-aperture imaging systems." Appx78, 1:55–56. A multi-aperture imaging system could be implemented in a digital camera and "includes a plurality of optical sub-systems (also referred to as 'sub-cameras')." Appx78, 1:56–59.

The '408 patent itself identifies examples of multi-aperture imaging systems known in the art to achieve zoom effect. Appx78, 1:55–56, 2:7–9 (citing and discussing Appx2564–2580). For example, the background section describes a patent publication (Border), published in 2008, in which "two sensors are operated simultaneously to capture an image imaged through an associated lens," where "[t]he two lenses have different focal lengths." Appx78, 2:9–13. Thus, "even though

each lens/sensor combination is aligned to look in the same direction, each captures an image of the same subject but with two different fields of view (FOVs)." Appx78, 2:13–16. Of those two lens/sensor combinations, one may image a "Wide" angle view, and the other "Tele" lens may image a narrower angle. Appx78, 2:16–17. Each provides a separate image, referred to as a "Wide" and a "Tele" image, respectively. Appx78, 2:18–19. The '408 patent also describes U.S. Patent Publication 2010/0277619 to Scarff, published in 2010, which similarly "teaches a camera with two lens/sensor combinations, the two lenses having different focal lengths." Appx78, 2:35–36.[1]

B. The '408 patent discloses a dual-aperture (dual-lens) zoom digital camera.

Like the prior art multi-aperture systems discussed above, the '408 patent, titled "dual aperture zoom digital camera,"[2] pertains to digital cameras with two sub-cameras: one "wide" sub-camera and one "tele" sub-camera. Appx68

[1] U.S. Patent Publication 2010/0277619 issued as U.S. 8,553,106. *See* Appx2169–2175.

[2] The '408 patent notes that "dual-aperture" may be referred to as "dual-lens" or "two-sensor." Appx79, 3:30–32.

(capitalization omitted), Appx79, 3:32–35. The earliest possible priority date of the '408 patent is June 13, 2013.[3]

More specifically, the '408 patent's specification describes "[a] dual-aperture zoom digital camera operable in both still and video modes." Appx68, Abstract. Much like the multi-aperture systems already in the art, "[t]he camera includes Wide and Tele imaging sections with respective lens/sensor combinations." Appx68, Abstract. The Wide and Tele sub-cameras each include "a fixed focal length lens, an image sensor and an image signal processor (ISP)." Appx79, 3:33–35. "The Tele sub-camera is the higher zoom sub-camera and the Wide sub-camera is the lower zoom sub-camera." Appx79, 3:35–37. Again like the prior art systems above, the two sub-cameras capture images of the same scene at different magnifications. Appx79, 3:57–60.

The specification also describes the digital camera as having "a camera controller operatively coupled to the Wide and Tele imaging sections." Appx68, Abstract. In video mode, the controller is used to "provide without fusion continuous zoom video mode output images, each output image having a given output resolution, wherein the video mode output images are provided with a

[3] Patents related to the '408 patent are currently pending before this Court in Appeal Nos. 22-1340/22-1341 and 22-1455/22-1456. The claims in those cases differ substantially from the claims in this appeal.

smooth transition when switching between a lower zoom factor (ZF) value and a higher ZF value or vice versa." Appx68, Abstract; *see also* Appx79, 3:51–56 (describing zoom in video mode "without fusion").

A block diagram of the dual-aperture digital camera is shown in Figure 1A of the '408 patent, below:

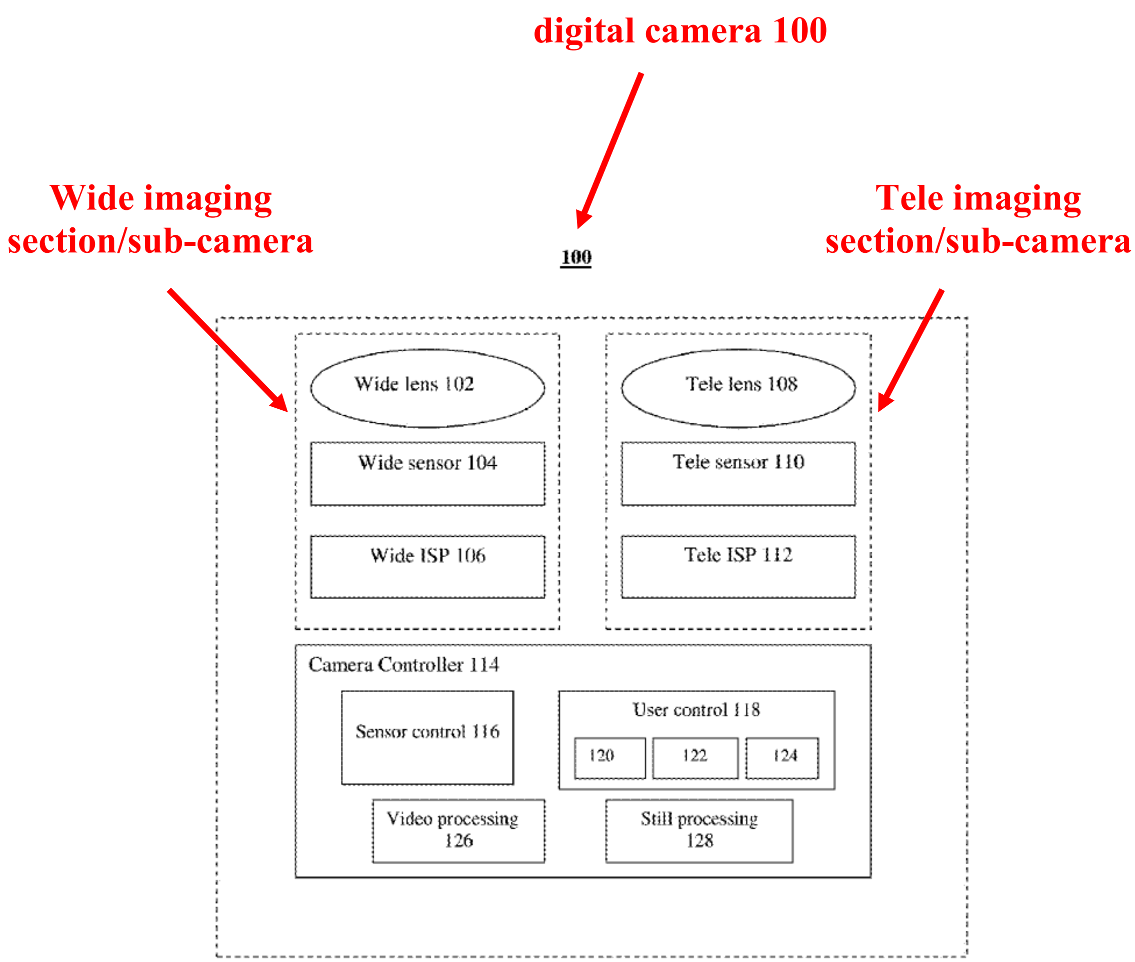


FIG. 1A

Appx70, Fig. 1A (annotated for appeal); *see also* Appx80, 6:18–26.

The '408 patent's specification describes various aspects of how its dual-lens digital camera operates in still and video modes. Those disclosures, however, are not pertinent to the independent claim challenged here. Independent claim 5 does not refer to a "camera controller" or how the controller uses multiple images to produce still or video output. Instead, claim 5 merely requires (1) two "imaging section[s]," where each "imaging section" includes "a fixed focal length" lens and a corresponding "image sensor," and where the second lens has a narrower field of view (FOV) than the first lens; and (2) that the "second lens" has a particular lens configuration (*i.e.*, a certain number of lens elements with certain basic optical properties). Appx84. Dependent claim 6 then adds a "camera controller" coupled to the two "imaging sections" to provide video output that has a "smooth transition when switching between a lower zoom factor (ZF) value and a higher ZF value or vice versa." Appx84.

The specification also contains two paragraphs explaining that "[a]dditional optical design considerations were taken into account to enable reaching optical zoom resolution using small total track length (TTL)," specifically with respect to the digital camera's Tele lens. Appx83, 12:38–41. Two embodiments of a Tele lens are described and shown in Figures 8 and 9. Appx83, 12:38–62. The embodiment in Figure 9, below, is pertinent here:

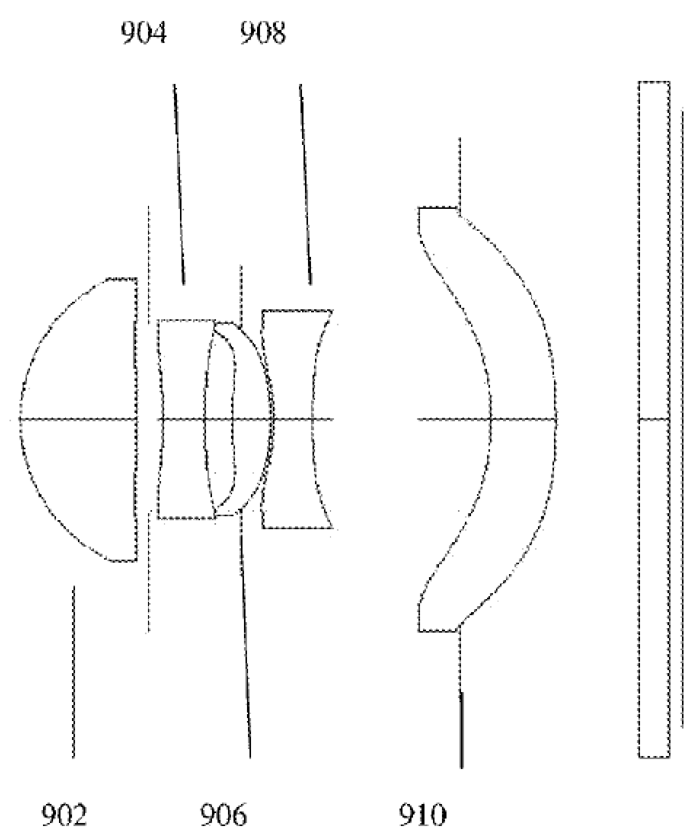


FIG. 9

Appx77, Fig. 9. Figure 9 illustrates a set of lens elements with the first lens element 902 having positive power, the second lens element 904 having negative power, the third lens element 906 having positive power, the fourth lens element having negative power, and the fifth lens element having positive or negative power. Appx83, 12:54–61.

Apple's IPR Petition in this case challenged two of the seven claims in the '408 patent (claims 5 and 6).[4] Independent claim 5 provides:

> 5. A zoom digital camera comprising:
>
> a) a first imaging section that includes a fixed focal length first lens with a first field of view (FOV_1) and a first image sensor; and
>
> b) a second imaging section that includes a fixed focal length second lens with a second FOV (FOV2) that is narrower than FOV, and a second image sensor, wherein the second lens includes five lens elements along an optical axis starting from an object starting with a first lens element with positive power, wherein the five lens elements further include a second lens element with negative power, a fourth lens element with negative power and a fifth lens element, wherein a largest distance between consecutive lens elements along the optical axis is a distance between the fourth lens element and the fifth lens element, and wherein a ratio of a total track length (TTL) to effective focal length (EFL) of the second lens is smaller than 1.

Appx84, 14:1–18. Claim 6 depends from claim 5 and provides as follows:

> 6. The zoom digital camera of claim 5, further comprising a camera controller operatively coupled to the first and second imaging sections, the camera controller configured to provide video output images with a smooth transition when switching between a lower zoom factor (ZF) value and a higher ZF value or vice versa.

Appx84, 14:19–24.

---

[4] Apple filed a separate IPR petition challenging claims 1–4 and 7. The Board denied institution in that case. *See* Apple Inc. v. Corephotonics Ltd., IPR2020-00488, Paper 9 (PTAB Aug. 3, 2020).

C. Golan and Kawamura each use fixed-focal length lenses to achieve a common goal of providing compact imaging systems with good image quality, as compared to imaging systems using traditional optical lenses.

The two references in Apple's combination shared a goal of moving away from traditional, heavy lenses and, instead, moving toward relatively lighter imaging systems. Golan improved over traditional optical zoom lenses by providing the desired zooming effect through multiple fixed-focal length lenses with lossless zooming. Kawamura improved over traditional telephoto lenses by using a specific lens configuration allowing for a compact telephoto lens with good imaging performance.

1. Golan discloses a video output with a continuous electronic zoom for an image acquisition system including multiple imaging devices having different fixed fields of view.

U.S. Patent Application Publication No. 2012/0026366 to Golan et al. ("Golan"), titled "Continuous Electronic Zoom for an Imaging System with Multiple Imaging Devices Having Different Fixed FOV," claims priority from a provisional application filed in April 2009. Appx1198. Golan discloses providing a video output with "a continuous electronic zoom for an image acquisition system, the system including multiple imaging devices having different fixed FOV." Appx1206, ¶ 2.

In describing the problem being solved, Golan contrasted traditional optical zoom lenses (which have variable focal lengths/variable FOVs and require moving mechanical elements) with digital or electronic zoom using fixed focal length lenses (which have fixed focal lengths/fixed FOVs and do not require moving mechanical elements). *See* Appx1206, ¶¶ 3–8. Like the '408 patent, Golan recognized that "[t]ypically, a camera with a large dynamic zoom range requires heavy and expensive lenses, as well as complex design." Appx1206, ¶ 7. In contrast, Golan explained that "*[e]lectronic zoom* does not need moving mechanical elements, as does optical zoom." Appx1206, ¶ 7 (emphasis added).

Further, Golan identified a problem with digital (or electronic) zoom. Digital zoom is performed by "cropping an image down" and "usually also interpolating the result back up to the pixel dimensions of the original." Appx1206, ¶ 3. This is done "without any adjustment of the camera's optics," and "no optical resolution is gained in the process." Appx1206, ¶ 3. Instead, because of the interpolation required, "[t]ypically some information is lost in the process." Appx1206, ¶ 3.

Thus, Golan identified multiple problems in the art. The lenses required for optical zooming were too heavy and complex. Meanwhile, in digital zooming, too much information was being lost over a full zoom range due to the required interpolation.

To address these problems, Golan identified a need for "image sensors, having *static, light weight electronic zoom* and a *large lossless zooming range*." Appx1206, ¶ 8 (emphasis added). Golan explained that lossless electronic zoom may be performed by "using image sensors having substantially higher resolution" than the image resolution required for a video stream. Appx1206, ¶ 4. Specifically, "[t]he ratio between the image sensor resolution and the output resolution dictates the lossless electronic zoom range." Appx1206, ¶ 4. Golan then provided a basic mathematical example to illustrate the concept of lossless electronic zoom:

> For example, having a 5 Megapixel, 2592x1944, image sensor array and an output resolution frame of 400x300 yields maximal lossless electronic zoom of 6:48:
>
> 2592/400=6.48,
>
> 1944/300=6.48.

Appx1206, ¶¶ 4–6.

Golan's Figure 1 showed such a multi-lens camera system:

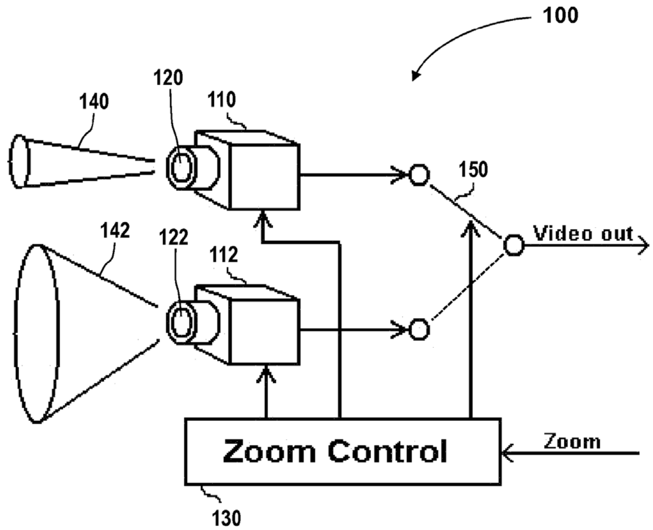


Fig 1

Appx1199, Fig. 1. Nowhere does Golan limit itself to a specific size of camera.

2. Kawamura discloses a compact telephoto lens with a five-lens configuration like that disclosed in the challenged claims.

Kawamura, titled "Telephoto Lens," describes a telephoto lens with five lens elements. Appx1299. Apple relied on Kawamura as disclosing the lens configuration aspects of the claimed "second lens" in independent claim 5 (*e.g.*, the number of lens elements, their respective positive/negative powers, the relative distance between the fourth and fifth lens elements, and the ratio of total track length to effective focal length). Appx199–211 (Petition).

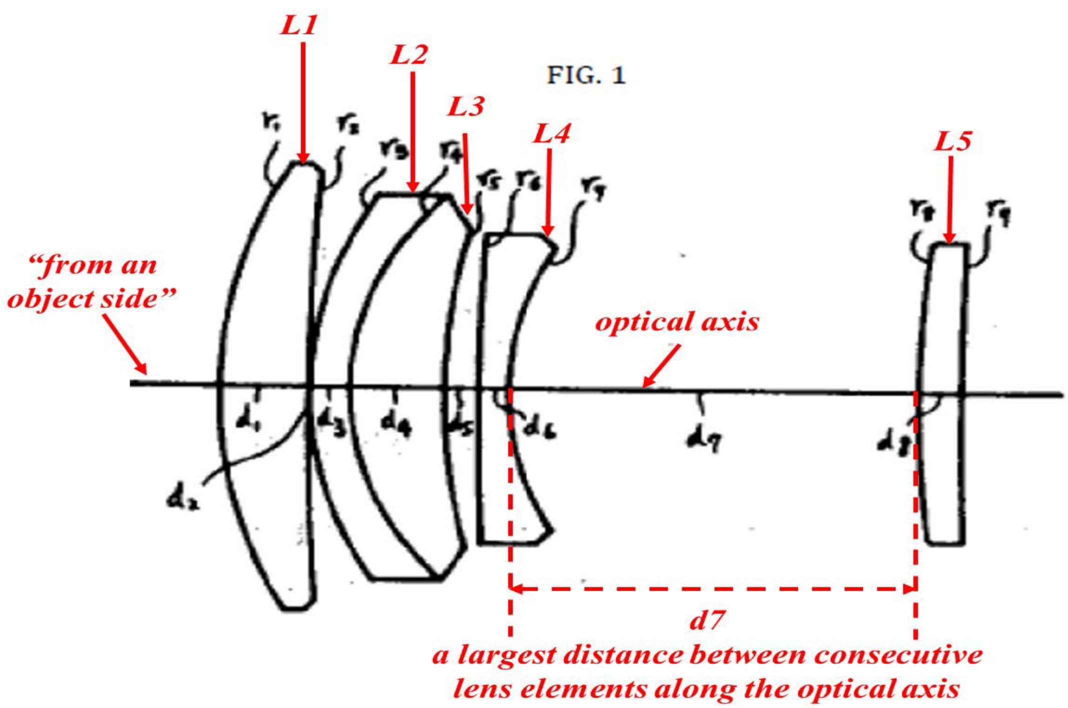
One stated goal of Kawamura's system was to "provide a lens that keeps a compactness of an overall length to a conventional level of a telephoto ratio of about 0.96 to 0.88," while offering "an excellent image-formation performance due to favorably correcting spherical aberration of both a reference wavelength and color and also decreasing chromatic aberration in magnification." Appx1299. In other words, Kawamura used specific optical properties of the lens configuration to achieve a more compact telephoto lens with improved imaging performance compared to what had traditionally been available.

Kawamura discloses multiple examples with five lens elements. Appx1304–1307, Figs. 1, 3, 6, and 8; *see also* Appx1301–1303 (providing numerical values of Examples 1–4).

To achieve the goal of maintaining compactness while providing excellent image-formation performance, Kawamura teaches that each embodiment satisfies a series of eight conditions. Appx1299–1300. Those conditions are designed in part to establish a "focal length necessary to set a telephoto ratio to about 0.96 to 0.88 and form a framework of the telephoto lens that favorably corrects aberration." Appx1300. Another condition relates "to a position of the fifth lens" so that if the value exceeds the upper limit of the condition, "a diameter of the fifth lens is too large to maintain an appropriate peripheral light amount, which is not preferable in

terms of frame configuration." Appx1300. Conversely, if the value "is smaller than the lower limit, coma aberration arises, which is not preferable due to correction thereof being difficult." Appx1300.

For each example, Kawamura provides figures and a configuration table including numerical values for the design Appx1304–1307, Figs. 1, 3, 6, and 8; *see also* Appx1301–1303. For example, an annotated version of Figure 1 (Example 1) and its corresponding configuration table are reproduced below:



Appx1131 (Sasián Decl.) (annotating Appx1304, Fig. 1).

Example 1

1 : 4.1 F = 200.079 ω = 12.3°.

NO.	r	d	N	ν
1	57.091	9.00	1.60311	60.7
2	330.000	0.20		
3	45.039	4.00	1.67270	32.1
4	33.450	9.60	1.48749	70.1
5	81.000	3.50		
6	387.380	3.00	1.57501	41.5
7	34.361	41.80		
8	146.228	4.34	1.74950	35.3
9	552.040			

d7
a largest distance between consecutive lens elements along the optical axis

$F_{1\cdot2\cdot3} = 74.912$

$F_{1\cdot2\cdot3\cdot4} = 356.466$

$d_1 + d_2 + d_3 + d_4 + d_5 + d_6 = 29.3$

Appx1132 (Sasián Decl.) (annotating Appx1301, Table for Example 1).

As reflected above, "the telephoto lens configuration of Kawamura includes five lens elements annotated as L1 through L5, and a largest distance between consecutive lens elements along the optical axis is a distance d7 between the fourth lens element and the fifth lens element." Appx1132, ¶ 58 (Sasián Decl.).

D. Procedural History

1. Apple's IPR Petition

In February 2020, Apple filed a petition for *inter partes* review, challenging claims 5 and 6 under the following obviousness ground:

Claims	**Prior Art**
5, 6	Golan, Kawamura

Appx178; *see generally* Appx163–226 (Petition). Apple supported its Petition with the expert testimony of Dr. José Sasián, a tenured Professor of Optical Sciences at the College of Optical Sciences at the University of Arizona. Appx1111; *see generally* Appx1106–1173.

After Corephotonics filed a Preliminary Response, the Board instituted an *inter partes* review in July 2020. Appx269.

2. Apple demonstrated multiple reasons to use Kawamura's compact telephoto lens with Golan's techniques for providing a compact digital zoom camera.

In addition to demonstrating how the prior art discloses each element of the challenged claims, Apple's Petition presented multiple reasons why a POSITA would have combined the teachings of Golan and Kawamura to render the challenged claims obvious.

First, citing Dr. Sasián's expert declaration, Apple's Petition explained that a "POSITA would have been motivated to apply Kawamura's teachings of a telephoto lens including five lens elements in the digital camera of Golan to produce the obvious, beneficial, and predictable results of a digital camera including a tele lens with a compactness of an overall length while having an excellent image-formation

performance as taught by Kawamura." Appx187 (citing Appx1132–1136, ¶¶ 60–64). Apple further explained that "[b]ecause Golan does not provide specific lens prescriptions, . . . a POSITA would have been motivated to apply Kawamura's teachings of tele lens because of the imaging benefits and compactness of an overall length with excellent image-formation performance as taught by Kawamura." Appx187 (citing Appx1132–1133, ¶ 60).

As further evidence demonstrating why a POSITA would have combined Golan and Kawamura, Apple presented the following:

- Golan and Kawamura are in the same field of endeavor pertaining to imaging systems including a telephoto lens. Appx187 (citing Appx1133, ¶ 61).
- Golan and Kawamura "share a need to provide a compact and lightweight imaging system while providing excellent image [quality]." Appx188 (citing Appx1133–1134, ¶ 62); *see also* Appx1198, Abstract, Appx1206, ¶¶ 4, 7–8, Appx1299.
- "a POSITA would have recognized that Kawamura's telephoto lens provides additional benefits, including for example, a relatively large field of view and little vignetting." Appx188 (citing Appx1133–1134, ¶ 62).

Moreover, as Apple's expert explained, "combining Kawamura's teachings of telephoto lens design in the digital camera of Golan would have been no more than the combination of known elements according to known methods (such as modifying the tele lens 120 in zoom control subsystem of Golan according to Kawamura's teachings), and would have been obvious to a POSITA at the time of the '408 patent

to achieve the benefits of a compact imaging system with excellent image performance described by Kawamura." Appx189 (citing Appx1134–1135, ¶ 63). Apple's expert also explained that this could be accomplished without the physical incorporation of Kawamura's telephoto lens into the digital camera of Golan. Appx189 (citing Appx1134–1135, ¶ 63).

Apple also presented evidence demonstrating that a POSITA would not have been concerned about the particular size of lens to use with Golan's techniques. Appx1135–1136, ¶ 64. Apple's expert explained that, even if modifications to Kawamura's telephoto lens were necessary, "such modifications would have been within the level of ordinary skill in the art." Appx189 (citing Appx1134–1135, ¶ 63). Indeed, "lens scaling was a well-known practice in lens design, and a POSITA would have scaled the Kawamura lens prescriptions to fit into a digital camera of Golan while maintaining the compactness and an excellent image-formation performance." Appx190 (citing Appx1134–1135, ¶ 63 (Sasián Decl.)).

3. Corephotonics' Patent Owner Response

In its Response, Corephotonics did not dispute that the combination discloses every limitation of independent claim 5. *See* Appx15 (FWD), Appx635, 25:1–10

(H'rg Tr.). Instead, Corephotonics focused solely on whether a POSITA would have been motivated to combine Golan and Kawamura.[5]

The underlying premise of each of Corephotonics' arguments was that Golan "calls for the use of miniature digital sensors" and that, because cameras with such sensors are "considered miniature cameras," Golan "contemplates the use of miniature camera modules." Appx315, Appx335. Corephotonics contended that Kawamura's lens would have been considered heavy, and that "[m]echanical zoom lenses much lighter than the unscaled Kawamura lenses were commonly available." Appx346–347 (citing Appx3256, ¶ 74 (Moore Decl.)).

4. Apple's Reply

In Reply, Apple explained that Golan's teachings are not limited to miniature cameras (*e.g.*, cell phones). Appx391–407 (Reply). Instead, Golan's technique for using a multi-lens, fixed-focal-length system (as opposed to a heavy optical zoom lens) while also achieving lossless zoom applies broadly to dual-lens cameras of *all* sizes, including to larger camera systems and lenses (like the one in Kawamura) and to commercial applications such as air-borne/drone cameras. Appx392 (citing

[5] Though not relevant to this appeal, Corephotonics' arguments regarding dependent claim 6 were based on its proposed construction of the term "smooth transition." Appx365–367. The Board did not address the parties' claim construction dispute given its dispositive holding regarding a motivation to combine the references. Appx11–12.

Appx2187, ¶ 16 (Sasián Reply)). Apple explained that Golan does not establish any dimension limitations on its imaging system or its image sensors and, thus, that a POSITA would have understood the basic principles taught by Golan to apply to imaging systems of various sizes. Appx392 (citing Appx2187, ¶ 16).

To further demonstrate the lack of any size restrictions in Golan, Apple presented evidence that a POSITA would have understood Golan's teachings to apply outside the context of mobile devices. Appx392–393 (discussing APPL-1035 (Appx3196), APPL-1022 (Appx2581–2593), APPL-1024 (Appx2602–2604), APPL-1026 (Appx3018–3023), and APPL-1030 (Appx3116–3122)).

5. Corephotonics admits in its Sur-reply and during the oral hearing that "Golan could be used in any system, miniature or otherwise."

As discussed below, by the time of the oral hearing, Corephotonics admitted that "Golan could be used in *any system, miniature or otherwise,* where the optical zoom is not available." Appx632, 22:8–9 (emphasis added).

More specifically, in its Sur-reply, Corephotonics maintained that Golan "teaches away from the use of 'heavy' lenses." Appx421; *see also* Appx421 (arguing a POSITA "would see Golan as pointing away from designs that are wildly heavier than Golan's examples"). Yet, in developing its argument, Corephotonics admitted that Golan is *not* limited to the 5-megapixel sensor example noted in Golan's

background section. Appx424 ("Apple argues that Golan does not 'require' a 5 megapixel sensor or a 1/4- or 1/3-inch sensor. *This is true.*" (emphasis added)), Appx424 ("While the 5-megapixel sensor is not a hard requirement of Golan, ..."). Corephotonics instead contended that the 5-megapixel sensor example used by Golan to illustrate lossless zooming was instead "a yardstick by which to judge whether a lens is consistent with Golan's teachings of a light-weight zoom and to understand that Kawamura's lens is heavier than what Golan contemplates" by a large factor. Appx424–425.

During the oral hearing, Corephotonics further clarified its understanding of Golan. In particular, Corephotonics focused on the relative pros and cons of Golan's system as compared to traditional optical zoom lenses:

> So, Golan really is directed to a miniature, smaller camera system. And I don't want to get hung up on what miniature means. ***We're not saying it has to be mobile. What we know is that it's using two fixed focal length cameras to use electronic zoom to approximate optical zoom where optical zoom and optical zoom lens would be too heavy or big.*** So, that may differ on the application, I agree, but if you've got an optical lens, that's better than using two different ones and it comes at a cost of resolution. . . . The whole point of Golan is to use approximate -- to use electronic zoom to approximate -- optical zoom where you can't have optical zoom. Optical zoom is better. It doesn't give you a loss of resolution. Optical zoom is better, but under some circumstances, those lens would be too big or heavy, according to Golan, and then this is a good substitute to use two different lenses and electronic zoom to approximate.

Appx629–630, 19:20–20:13. In response to a question regarding whether a POSITA would consider Golan's teachings to apply to both miniature cameras and large-scale cameras, Corephotonics' counsel admitted that Golan *could* be used with larger (non-miniature) camera systems:

> Golan could be used in *any system, miniature or otherwise,* where the optical zoom is not available. You would only use it a poor substitute [sic] as an approximation for an optical zoom in a system where an optical zoom lens is not available.

Appx632, 22:4–11 (emphasis added). Corephotonics' counsel acknowledged that "you could use it [Golan] in a larger system, but the reason why you wouldn't is it's an approximation of optical zoom, you lose resolution by doing electronic zoom . . . the only reason to do it would be if an optical zoom is not available." Appx632, 22:12–16. Corephotonics' counsel further explained that "it's not that it [Golan] has to be limited to mobile systems specifically, but it does teach that it's limited to systems or one or skilled in the art would understand that you would only use it where an optical zoom is not available." Appx632, 22:17–20.

Corephotonics' point, in short, was that a POSITA in 2013 would not have looked to Kawamura unless there were an absence of *optical zoom* (also called mechanical zoom) lenses that were the same size or smaller than Kawamura. Appx637, 27:23–26. And, in Corephotonics' view, optical/mechanical zoom

cameras existed that were smaller than Kawamura. Appx635, 25:18–20, Appx346–347 (citing Appx3256, ¶ 74 (Moore Decl.)).

6. The Final Written Decision and Rehearing Denial

Seemingly ignoring the statements at the Oral Hearing, the Board held that Apple had not demonstrated a motivation to combine Golan and Kawamura. Appx39. In reaching that finding, the Board focused almost exclusively on the 5-megapixel example in Golan's background section (which Golan used only to explain "lossless" zooming). Appx33–35. The Board then extrapolated from that single 5-megapixel example to create an approximate lens size or weight purportedly contemplated by Golan. *See* Appx34–35.

The Board found the evidence did not show that a POSITA would have understood Kawamura's lens to have "'compactness of an overall length' such that Kawamura's lens assembly would have been understood to address the needs identified in Golan and Golan's 'goal to provide an imaging device with '*light weight*' electronic zoom." Appx25–26. In reaching that conclusion, the Board specifically found that "there is insufficient evidence of record to support the proposition that Golan's teachings are applicable to imaging systems that are of a scale larger than that of the miniature cameras and image sensors used in mobile devices." Appx26. From that point forward, the Board effectively viewed Golan as being limited to

miniature cameras. This caused the Board to view Kawamura's lens as much heavier than what was contemplated by the term "light weight" in Golan, which served as the Board's basis for rejecting Apple's primary reason why a POSITA would have combined the two references and further tainted the Board's analysis of Apple's additional arguments. Appx34–35.

Apple sought rehearing of the Board's Decision, which the Board subsequently denied. Appx43–67.

SUMMARY OF THE ARGUMENT

The Board's determination that a person of ordinary skill in the art would not have combined Golan and Kawamura as proposed cannot be sustained for multiple reasons:

First, the Board fundamentally misunderstood one of the prior art references (Golan) by limiting its teachings to miniature digital cameras (*e.g.*, those used in cell phones). Oddly, the Board found that the record did not support a finding that Golan's teachings regarding electronic zoom were applicable to larger camera systems, even though both parties agreed that Golan's teachings were, indeed, applicable to larger systems. For instance, Corephotonics' counsel explained during the oral hearing before the Board that "Golan could be used in *any system, miniature or otherwise*, where the optical zoom is not available." Appx632, 22:8–9 (emphasis

added). Further, nothing in Golan expressed any preference for a certain camera size or context in which Golan's teachings regarding lossless electronic zoom could be used. To create such an indication, the Board had to rely on a single background example in Golan that discussed a 5-megapixel image sensor, which Golan used for an entirely different purpose, *i.e.*, to show the mathematical calculations underlying lossless zoom (rather than to discuss anything regarding lens size). Yet despite Corephotonics' own admissions regarding Golan's broad applicability, and despite the lack of any limitation in Golan on lens size, the Board still found that Golan's teachings would *not* apply to larger (non-miniature) camera systems and, thus, that a POSITA would not have used Golan's teachings with the larger lens found in Kawamura. This was a blatant factual error by the Board that itself justifies reversal or, at a minimum, remand.

Second, with that factual misunderstanding in hand, the Board then placed an improper burden on Apple to affirmatively demonstrate that Golan would not teach away from the claimed invention. In doing so, the Board effectively asked Apple to prove a negative. And while Apple did submit evidence showing that Golan's teachings would be used in larger camera systems, including a patent from the same patent family to the same inventors, the Board dismissed that evidence as insufficient and ultimately faulted Apple for failing to show that Golan would be used with larger

cameras, even though Golan was never limited to miniature cameras in the first place.

Third, the Board compounded the errors in its analysis of the prior art by then using its erroneous finding regarding the scope of Golan's teachings to compare the purported sizes of Golan and Kawamura. Such a comparison would have only made sense if a POSITA would have needed to physically incorporate Kawamura's lens into Golan's imaging system. But "it is not necessary that the inventions of the references be physically combinable to render obvious the invention under review." *In re Sneed*, 710 F.2d 1544, 1550 (Fed. Cir. 1983). This analysis was legal error by the Board. Further, the Board erred factually in its comparisons by again extrapolating from Golan's irrelevant example of a 5-megapixel image sensor to conclude that Golan's reference to "light weight electronic zoom" reflected a comparison of whether a lens would have been considered "light weight" compared to a miniature camera. That finding was again based on the Board's misapplication of Golan's 5-megapixel example, and the evidence the Board cited fails to support the Board's understanding of Golan whatsoever. Golan's reference to "light weight electronic zoom" reflects the solution presented to the problems in the art—and that comparison was between heavy *optical zoom* lenses offering a mechanically variable range of focal lengths, versus Golan's lighter *electronic zoom* system using multiple,

and much smaller, fixed focal length lenses to provide a comparable zoom range. Thus, the Board's findings regarding Golan's use of the relative term "light weight" also lack evidentiary support.

Finally, in addition to the errors above, the Board also erred procedurally by failing to consider all of Apple's stated reasons for combining Golan and Kawamura.

For these reasons, the Court should reverse the Board's unpatentability determinations, hold at least independent claim 5 unpatentable as obvious, and remand for further consideration of the parties' arguments regarding dependent claim 6. Alternatively, the Court should at least remand with respect to both challenged claims.

STANDARD OF REVIEW

This Court reviews the Board's IPR decisions "to ensure that they are not 'arbitrary, capricious, an abuse of discretion, . . . otherwise not in accordance with law . . . [or] unsupported by substantial evidence.'" *Personal Web Techs., LLC v. Apple Inc.*, 848 F.3d 987, 992 (Fed. Cir. 2017) (quoting 5 U.S.C. § 706(2)(A), (E) and citing *Pride Mobility Prods. Corp. v. Permobil, Inc.*, 818 F.3d 1307, 1313 (Fed. Cir. 2016)).

The Board's legal conclusions are reviewed de novo, while its factual findings are reviewed for substantial evidence. *Arendi S.A.R.L. v. Apple Inc.*, 832 F.3d 1355,

1360 (Fed. Cir. 2016). "Obviousness 'is a question of law based on underlying findings of fact.'" *SIPCO, LLC v. Emerson Elec. Co.*, 980 F.3d 865, 870 (Fed. Cir. 2020) (quoting *In re Gartside*, 203 F.3d 1305, 1316 (Fed. Cir. 2000)). This Court reviews "the Board's findings regarding the scope and content of the prior art for substantial evidence." *Id.*

"The ultimate judgment of obviousness is a legal determination." *KSR Int'l Co. v. Teleflex Inc.*, 550 U.S. 398, 427 (2007); *see also Graham v. John Deere Co.*, 383 U.S. 1, 17 (1966) ("[T]he ultimate question of patent validity is one of law . . . ."). The obviousness inquiry "lends itself to several basic factual inquiries," including "the scope and content of the prior art"; "differences between the prior art and the claims at issue"; and "the level of ordinary skill in the pertinent art." *Graham*, 383 U.S. at 17; *see also ESIP Series 2, LLC v. Puzhen Life USA, LLC*, 958 F.3d 1378, 1383 (Fed. Cir. 2020). This Court has stated that the presence or absence of a motivation to combine references is a question of fact. *Gartside*, 203 F.3d at 1316; *but see Panduit Corp. v. Dennison Mfg. Co.*, 810 F.2d 1561, 1568 (Fed. Cir. 1987) (characterizing the requirement of a suggestion to combine references as a "legal standard" to guide "fact-finding functions performed en route to final § 103 conclusions"); Joshua L. Sohn, *Re-Thinking the "Motivation-to-Combine" in Patent Law*, 48 AIPLA Q.J. 1, 4

(2020) (arguing motivation to combine should be viewed as a question of law lest it "swallow[] up the entire obviousness analysis").

ARGUMENT

This appeal arises from the Board's failure to conclude that claims 5 and 6 of the '408 patent would have been unpatentable as obvious. The Board's Decision is tainted at every step by the faulty presumption that one prior art reference (Golan) is narrowly limited to miniature devices and could not, therefore, be combined with a reference disclosing exemplary lens embodiments addressing larger-scale cameras (Kawamura). But Golan is not limited to miniature devices. Even if it were, the relative size of the prior art references was not the basis of Apple's motivation to combine the references. Those bases—analogous art in the same field of endeavor, shared goals, maintenance of image quality, predictable results, the interrelated teachings of Golan and Kawamura that would render the combination desirable, and the added benefits deriving from Kawamura's large field of view and little vignetting—are scarcely mentioned in the Final Written Decision.

Here, the Board built a straw man regarding the relative size of the prior art devices and then imposed an insurmountable obligation on Apple to strike down that straw man without regard to the other stated reasons and evidence supporting the combination. In so doing, the Board erroneously interpreted the prior art references

and ignored the true articulated bases and evidence supporting a motivation to combine. Correcting these errors and looking to the relevant evidence, the Final Written Decision should be reversed.

I. The Board erred both factually and legally by determining that there was insufficient evidence to show that Golan's teachings could be applied to larger camera lenses, such as Kawamura's lens.

A. Factually, the Board erred by ignoring the parties' shared understanding that Golan could be applied to camera systems of any size.

The Board's finding that "there is insufficient evidence of record to support the proposition that Golan's teachings are applicable to imaging systems that are of a scale larger than that of the miniature cameras and image sensors used in mobile devices" should be reversed for at least the simple reason that both parties agreed that Golan's teachings would apply to larger camera systems. The Board's contrary findings misunderstood the evidence and addressed an argument different than the one Corephotonics actually made.

At the outset, there is no dispute that Golan does *not* require use of a 5-megapixel image sensor. Corephotonics admitted in its Sur-reply that Golan is not limited to the 5-megapixel sensor example in Golan's background section. Appx424 ("Apple argues that Golan does not 'require' a 5 megapixel sensor or a 1/4- or 1/3-inch sensor. This is true."), Appx424 ("While the 5-megapixel sensor is not a hard requirement of Golan, ...").

There is also no dispute that Golan's teachings would apply to *any* size camera system—not just miniature cameras or miniature lenses. Corephotonics' counsel admitted during the oral hearing that "Golan could be used in any system, *miniature or otherwise*, where the optical zoom is not available." Appx632, 22:8–9 (emphasis added). Similarly, there is no dispute that Golan's system could be used with Kawamura and that the combination would be operable. *See* Appx633, 23:1–2 (H'rg Tr.) (Corephotonics' counsel stating "it's not that you couldn't, it's that you wouldn't and there wouldn't be any motivation to do so").

Despite these basic factual agreements between the parties regarding Golan, the Board erroneously found that "there is insufficient evidence of record to support the proposition that Golan's teachings are applicable to imaging systems that are of a scale larger than that of the miniature cameras and image sensors used in mobile devices." Appx26. That finding is directly contrary to Corephotonics' admission that "Golan could be used *in any system, miniature or otherwise*, where the optical zoom is not available." Appx632, 22:8–9 (emphasis added). It is also untethered from any disclosure in Golan. Golan does not provide any limitations—or even preferences—regarding what camera sizes its system could be used with. This fundamental factual error tainted the entirety of the Board's motivation analysis.

For context: based on Corephotonics' Patent Owner Response, which only briefly addressed Apple's arguments regarding combining Golan and Kawamura, it appeared that Corephotonics was taking the position that Golan could *only* be applied to miniature cameras (such as those in cell phones), based on Golan's reference to a 5-megapixel sensor in its background section. *See* Appx346–347. That ambiguity resulted in extensive discussion by the parties (including additional evidence) regarding whether Golan's technique could be applied to larger camera systems. Appx391–395 (Reply, discussing APPL-1035 (Appx3196), APPL-1022 (Appx2581–2593), APPL-1024 (Appx2602–2604), APPL-1026 (Appx3018–3023), and APPL-1030 (Appx3116–3122) (exhibits regarding NextVision products and a related patent)).[6]

Regardless, by the time of the oral hearing, the issues had crystalized, and it was clear that no party believed Golan's teachings to be *limited* to miniature lenses. *See, e.g.*, Appx632, 22:4–20, Appx637, 27:23–26. Instead, Corephotonics' position

[6] For example, Apple presented evidence that a related patent to the same inventors and owned by the same assignee ("Golan '697") described use of an imaging system "operatively mounted on an air-born vehicle." Appx2587, 1:14–18. Despite the fact that Golan '697 is related to Golan based on a shared claim of priority to a provisional application (App. No. 61/167,226), the Board did not find Golan '697 relevant to understanding Golan's applicability to non-miniature camera systems. *See* Appx30–31, Appx56–57; *compare* Appx1198, code (60), *with* Appx2581, code (60), Appx2587, 1:7–9.

was that Golan generally sought to avoid use of "heavy" lenses, and that Kawamura's lens would have been considered "heavy." *See* Appx346–347 (Resp.). Corephotonics specifically contended that "[m]echanical zoom lenses much lighter than the unscaled Kawamura lenses were commonly available," Appx346–347 (citing Appx3256, ¶ 74 (Moore Decl.)), and thus, that there would have been no reason to use Kawamura's lens with Golan's electronic zoom system. Put another way, Corephotonics believed that a POSITA would not have applied Kawamura's lens design in a Golan-type multiple fixed lens design because it believed that better lens options would have been available. *See* Appx346–347. Thus, Corephotonics contended that Golan "teaches away" from a combination with Kawamura's lens. That argument by Corephotonics was not borne out by the evidence presented. But, the Board ultimately did not even address that more nuanced argument by Corephotonics because of the Board's perpetual focus on the miniature-image-sensor example in Golan's background section.

In other words, instead of analyzing the parties' arguments as they had developed by the time of the oral hearing, the Board focused the majority of its Final Written Decision on a side dispute that had essentially become moot by the time of the Final Written Decision.

Thus, in light of the parties' agreement on that fundamental question, there was no need for the Board to spend eight pages of its Final Written Decision discussing that separate set of Apple's evidence. *See* Appx26–33. Instead, the Board should have noted the parties' agreement that Golan could be applied to camera systems *other than* miniature cameras and then analyzed the parties' motivation-related arguments with that in mind. But the Board's fundamental error at this early stage tainted the remainder of its analysis in the Final Written Decision.

The Board stated that the 5-megapixel example "supports the finding that Golan is *at least* applicable to miniature digital cameras." Appx34 (emphasis added). But the Board used that isolated example (taken entirely out of context) to create an unfounded assumption about Golan's applicability that it then expected Apple to rebut. For example, the Board stated elsewhere that "the 5 megapixel image sensor array is the only disclosure in Golan which might indicate to a POSITA what scale of lens assembly Golan's teachings would be applicable to." Appx34. The problem, though, was that there was no reason for the Board to assume that Golan had *any* limitations on size when Golan says nothing about size limitations. And, the Board particularly had no need to contemplate size limitations when Corephotonics itself agreed that Golan could be applied to "any system, miniature or otherwise."

Appx632, 22:8–9.[7] Moreover, that passing reference to a 5-megapixel image sensor does not provide any indication regarding what size camera should be used because that example was presented in the context of explaining lossless zoom—not as an example of lens size. *See* Appx1206, ¶¶ 4–6 (Golan).

In sum, the Board took Golan's 5-megapixel example out of context, then viewed it as "providing the only context in the record for the scale of device or device components to which Golan's teachings are applied." *See* Appx33–34. The Board then extrapolated from that passing reference to a 5-megapixel image sensor to create an assumption that Golan would not be applicable to any other size camera systems simply because such systems are not expressly mentioned. That finding was unsupported by Golan's disclosure and, critically, was inconsistent with how both parties understood Golan. Accordingly, the Court should reverse the Board's

[7] The Board's statement that the 5-megapixel example shows that Golan "at least" applies to miniature cameras does not suggest that Golan should be viewed as applying *only* to miniature cameras unless proven otherwise by Apple. *See* Appx34. Yet the Board then immediately concluded that "there is no disclosure or evidence that discloses that Golan's teachings are applicable to larger-scale imaging systems, nor is there evidence of record that sufficiently supports a finding that a POSITA would have understood Golan's teachings to be applicable to larger-scale imaging systems, such as those of the size able to accommodate a lens assembly of size disclosed in Kawamura." Appx34.

Decision and, at the very least, remand for consideration of Apple's obviousness arguments without this erroneous assumption in place.

B. The Board improperly obligated Apple to prove Golan does not "teach away" from larger-scale imaging systems like Kawamura.

Clinging to the erroneous assumption that Golan could not apply to anything other than miniature devices, the Board faulted Apple for effectively failing to prove Golan did not teach away from larger-scale imaging systems like Kawamura. *See, e.g.*, Appx26 (finding "insufficient evidence of record to support the proposition that Golan's teachings are applicable to imaging systems that are of a scale larger than that of the miniature cameras and image sensors used in mobile devices").

The Board did not use the words "teaching away" in the Final Written Decision, but Corephotonics argued expressly that Golan teaches away from larger-scale imaging systems like Kawamura. *See, e.g.*, Appx261 ("Golan specifically teaches away from using such a large, heavy lens."); *see also* Appx421 (Sur-reply) (stating that a POSITA "would see Golan as pointing away from designs that are wildly heavier than Golan's examples"). The Board's findings effectively adopt Corephotonics' reasoning in this regard, assuming that Golan was limited to and taught away from larger-scale lenses and implicitly imposing a duty on Apple to prove Golan did not teach away from anything other than miniature devices. *See, e.g.*, Appx26, Appx34 (citing Appx322–323 (Resp.), Appx1206, ¶ 4 (Golan)) (finding

Golan's teachings "applicable to miniature digital cameras and image sensors such as those used in mobile devices" and rejecting any suggestion that "a POSITA would have understood Golan's teachings to be applicable to larger-scale imaging systems, such as those of the size able to accommodate a lens assembly of size disclosed in Kawamura"). This was error.

Mere expression in a prior art reference of a preference for an alternative does not teach away from the claimed invention (or other art) unless the reference expressly "criticize[s], discredit[s], or otherwise discourage[s] investigation into the" claimed invention. *Gen. Elec. Co. v. Raytheon Techs. Corp.*, 983 F.3d 1334, 1345 (Fed. Cir. 2020) (internal quotations omitted); *Tyco Healthcare Grp. LP v. Ethicon Endo-Surgery, Inc.*, 774 F.3d 968, 977 (Fed. Cir. 2014) ("Yet simply because the curved blade configurations are not preferred embodiments does not result in the [] patent teaching away from use of a curved blade, absent clear discouragement of that combination."). Golan does not even express a preference for any particular size cameras. When read in context, the discussion of a 5-megapixel image sensor in Golan is merely used to illustrate a mathematical example of how "lossless electronic zoom" works. Appx1206, ¶¶ 4–6.

But even if Golan's teachings expressed a preference for miniature camera designs (which they do not), Golan does not expressly criticize, discourage, or

discredit application of its invention to larger-scale digital cameras and image sensors. Indeed, Golan does not even mention the word miniature. Appx1206–1209. Nor does it describe the invention by size. Rather, it describes the present invention as relating "to an electronic zoom for imaging systems, and more particularly, the present invention relates to a continuous electronic zoom for an image acquisition system, the system including multiple imaging devices having different fixed FOV." Appx1206, ¶ 2. Accordingly, the Board erred in effectively finding that Golan teaches away from a larger-scale camera and lenses such as disclosed in Kawamura and criticizing Apple for failing to disprove such an implication. *See, e.g.*, *Gen. Elec. Co.*, 983 F.3d at 1345–46 (holding that substantial evidence did not support the Board's conclusion that the prior art reference taught away from the proposed modification). For this additional reason, the Court should at least vacate the Board's Decision and remand for a proper analysis of the evidence.

C. The Board's incorrect understanding regarding Golan's applicability to larger systems also tainted the Board's analysis regarding Apple's scaling evidence.

After improperly focusing its analysis on the 5-megapixel example in Golan, the Board then carried that faulty presumption through its analysis of other aspects of Apple's motivation-related evidence, including Apple's arguments regarding scaling Kawamura's lens.

Apple presented evidence that, generally, scaling a lens prescription to another size was a well-known practice in lens design. Appx189–190. Apple's evidence demonstrated that a POSITA would have scaled the Kawamura lens prescription, if needed, to work with Golan's disclosures. Appx190. The law is clear, of course, that bodily or physical incorporation of one reference into another is not required to show obviousness. *See In re Mouttet*, 686 F.3d 1322, 1332 (Fed. Cir. 2012) (explaining the "test for obviousness is not whether the features of a secondary reference may be bodily incorporated into the structure of the primary reference" (internal quotations omitted)); *see also infra* Section II. Rather, the purpose of Apple's evidence regarding scaling was to confirm that questions of lens size would not have dissuaded a POSITA from combining Golan's techniques with Kawamura's telephoto lens design. Both parties presented evidence regarding scaling throughout the proceedings. *See* Appx35–37 (discussing aspects of that evidence).

In the Final Written Decision, however, the Board continued with its laser focus on the miniature-camera example in Golan and ultimately used that faulty presumption to then conclude that a POSITA would not have scaled Kawamura to the size of a *miniature* camera, rather than any other larger size. This is confirmed by

the evidence the Board cited in its brief analysis of Apple's scaling arguments. Appx35–37.

For instance, the Board cited paragraphs 76 and 77 of Corephotonics' expert's testimony. But that testimony is entirely conclusory and all-too-focused on Golan's 5-megapixel example. Dr. Moore never explained why any purported "improvements" between 1981 and 2009 or 2013 would have dissuaded a POSITA from scaling Kawamura's lens prescription with Golan. Appx3257, ¶ 76. Nor did Dr. Moore explain what "different purpose" or "different design constraints" Kawamura's lens was designed for, or why that would have dissuaded a POSITA from using Kawamura's lens with Golan. Appx3257–3258, ¶ 77. He merely explained the difference in scale between Golan's 5-megapixel example and Kawamura's lens, without explaining the significance of that difference. Appx3257–3258, ¶ 77. The Board's Decision is similarly devoid of any explanation as to why the degree of scaling would have dissuaded a POSITA. Appx36.

Indeed, even the evidence purportedly impeaching Dr. Sasián's testimony was limited solely to *miniature* cameras, which, again, was never Apple's focus with regard to its scaling evidence. *See* Appx36–37; EX2008, 1 (Appx3507) (referring specifically to the "design and packaging of a *miniature* camera lens module" as "impos[ing] optical design challenges" (emphasis added)); EX2013, 79 (Appx3618)

(discussing "Design Challenges of *Miniature* Camera Lens" (emphasis added)), EX2013, 83 (Appx3622) (discussing required "spatial tolerances" in the context of manufacturing difficulties for "*miniature* lenses" (emphasis added)); EX2006, 195 (Appx3486) (citing EX2012, 1 (Appx3529) (article titled "The Optics of *Miniature* Digital Camera Modules" that discuses "[d]esigning lenses for *cell phone* cameras" (emphasis added)). In other words, even if manufacturability concerns would have existed when scaling Kawamura to fit in a *miniature* camera, Apple's point was broader: given the lack of any specific size restraints in Golan, a POSITA would not have been dissuaded from combining Golan with Kawamura because general scaling principles would have left that line of creativity open, even if some constraints regarding manufacturing would have eventually come up in the context of *miniature* lenses.

Finally, in concluding that a POSITA would not have looked to Kawamura due to a purported "rich literature" of other options, the Board once again focused solely on miniature lenses. Appx36 (concluding a POSITA "'would not have been motivated to go beyond [the] rich literature of miniature lens designs and try scaling old lenses'" (quoting Appx3262–3263, ¶ 87 (Moore Decl.))). But this was error for two reasons.

First, it is legally erroneous. There is no requirement to show that one option would have been *better* than others. *See Intel Corp. v. Qualcomm Inc.*, 21 F.4th 784, 800 (Fed. Cir. 2021) ("It's not necessary to show that a combination is 'the *best* option, only that it be a *suitable* option.'" (emphasis original) (quoting *PAR Pharm., Inc. v. TWI Pharms., Inc.*, 773 F.3d 1186, 1197–98 (Fed. Cir. 2014)).

Second, even if focusing on miniature lenses had been a correct approach (which it was not), there was not a "rich literature of miniature lens designs" in 2013. *See* Appx36. In fact, just days after the Final Written Decision in this case, Corephotonics argued the *opposite* position to a patent tribunal in Korea. *See* Appx662–663 (R'hg Request), Appx680–710 ("Korean Brief"),[8] Appx3888–3998 (correspondence regarding request to admit Korean Brief). Specifically, Corephotonics argued to the Korean tribunal that "there were hardly any telephoto lens assemblies applied to portable terminals" in 2013 (Appx682), that "a [POSITA] did not think that the telephoto lens assembly could be installed in the portable terminal" (Appx687), and that, in 2013, "there was only one prior document that mounted the telephoto lens assembly on a portable terminal" (Appx682).

---

[8] Apple attached a certified translation of the Korean Brief to its Rehearing Request. *See* Appx44–46 nn.1–2. Apple could not have submitted the Korean Brief earlier because it was not filed until after the Final Written Decision issued in this case.

Those factual representations directly undermine Corephotonics' contentions—and the Board's finding—that a POSITA would not have looked to Kawamura's lens based on a "rich literature" of other options for miniature lenses. Appx36. The Board, however, declined to admit the Korean Brief as evidence. Appx52–53. Instead, the Board reasoned that the Korean Brief would not have affected its decision because "Dr. Moore refers to a breadth of miniature lens designs, whereas the Korean Brief more particularly refers to a dearth of telephoto lens assemblies *applied* to portable terminals—the record does not indicate that the portable terminals mentioned in the Korean Brief are necessarily miniature." Appx52. That finding made little sense, given that even Corephotonics acknowledged that "portable terminals" in the Korean Brief referred to "mobile phones," *i.e.*, miniature cameras. Appx789. Thus, Corephotonics' positions to the Korean tribunal directly contradicted its expert's testimony in this proceeding—testimony on which the Board relied to reject Apple's obviousness challenge. *See* Appx36. Although the Board suggested that it would have reached the same conclusion even without considering that expert testimony, the Board never explained why it would have reached the same conclusion—nor indicated what evidence would have supported that hypothetical situation. *See* Appx53. This itself

warrants reversal, or at least vacatur and remand, for the Board to reconsider its analysis without considering the unreliable testimony of Corephotonics' expert.

In sum, the Board's analysis of Apple's evidence regarding scaling was similarly tainted by the Board's incorrect view that Golan could not be used with non-miniature cameras. Accordingly, the entirety of the Board's analysis regarding scaling should similarly be vacated and remanded for a proper analysis, free from the Board's incorrect understanding that Golan could not be applied to larger-scale lenses.

II. The Board compounded its errors by extending the presumption that Golan could not be used in larger camera systems to find a dispositive difference in size between Golan and Kawamura, misunderstanding the evidence and improperly requiring bodily incorporation of one prior art reference into another.

Building on its errors above, the Board further erred, both legally and factually, by comparing the purported sizes of Golan and Kawamura. The Board's errors in this respect are three-fold.

First, the comparison of Golan's purported weight and Kawamura's weight is based solely on the faulty factual premise that Golan applies only to miniature cameras. *See supra* Section I. Once it is understood that Golan's techniques would have been used with larger lenses, such as the one in Kawamura, then no difference in weight or size would exist at all. Accordingly, the same factual error permeates

this aspect of the Board's analysis and justifies reversal for the same reasons discussed above. *See supra* Section I.

Second, comparing the purported sizes of Golan and Kawamura was legal error because that comparison assumed a need to physically incorporate Kawamura's lens into Golan. *See* Appx34–36. But "it is not necessary that the inventions of the references be physically combinable to render obvious the invention under review." *In re Sneed*, 710 F.2d 1544, 1550 (Fed. Cir. 1983); *see also Mouttet*, 686 F.3d at 1332 (explaining the "test for obviousness is not whether the features of a secondary reference may be bodily incorporated into the structure of the primary reference"); *In re Nievelt*, 482 F.2d 965 (CCPA 1973) ("Combining the teachings of references does not involve an ability to combine their specific structures."). Instead, "the test for obviousness is what the combined teachings of the references would have suggested to those having ordinary skill in the art." *Mouttet*, 686 F.3d at 1333.

Apple's obviousness analysis simply utilized the concepts taught by Kawamura (regarding a lens configuration for a compact telephoto lens) with the dual-lens system in Golan, without suggesting that such a combination would have required physically combining the two references. But instead of considering whether the teachings of the two references would have fairly suggested the

combination to a POSITA in light of the motivations Apple presented, the Board dismissed Apple's motivation arguments by erroneously focusing on the purported difference in size between Golan and Kawamura. *See* Appx34–36, Appx39.

When Apple identified this legal error in its Request for Rehearing (Appx677–678), the Board stated that it was not relying on bodily incorporation, but on a purported lack of evidence regarding a motivation to combine the references, "particularly in light of the above considerations relating to scaling." Appx66. But that's just it. Apple was not required to demonstrate that a POSITA would have scaled Kawamura's lens to fit into Golan (and particularly to fit into a miniature camera). *See* Appx35–36 (dismissing Apple's motivation evidence "particularly if it would have been necessary to scale Kawamura's lens assembly in order to modify Golan's teachings in Petitioner's proposed combination"), Appx36 (finding a POSITA "would not have been motivated to scale Kawamura for use in Golan"). Such a requirement would be based solely on physical incorporation of one reference into another, which the law does not require.[9] This provides an independent basis to reverse the Board's Decision and remand for a proper analysis not tied to whether a

[9] In any event, the Board's analysis of the scaling evidence was flawed, as discussed above. *See supra* Section I.C.

POSITA would have physically incorporated Kawamura's lens into Golan's imaging system.

Third, the Board erred by finding that a POSITA would have understood the terms "heavy," "expensive," and "light weight" in Golan to be "relative to what is disclosed in Golan, which is a miniature digital camera, and correspondingly-sized image sensors (e.g., 1/4″ or 1/3″ miniature digital sensors)." Appx34. Based on that unsupported finding, the Board concluded that Kawamura would not have addressed Golan's goal of providing "light weight electronic zoom." Appx25–26. But the Board's comparison of the weight of Kawamura's lens and the weight of miniature cameras asked the wrong question. Golan's reference to "light weight" was a comparison to traditional optical zoom lenses offering a zoom range comparable to that provided by Golan's multiple fixed focal length lenses and electronic zoom. And when compared to traditional optical zoom lenses, Kawamura's lens, used with Golan as proposed, would have been considered "light weight." This confirms that Golan and Kawamura were directed to the same goal of providing more compact imaging systems as compared to traditional lenses, which provides a reason why a POSITA would have combined those references.

The Board's reliance on Golan's 5-megapixel example is especially problematic when used to interpret Golan's references to "heavy," "expensive,"

and "light weight." Appx34. As Apple demonstrated, a POSITA would have understood that, in Golan, the terms "heavy," "expensive," and "light weight" are relative terms. Appx397 (citing Appx2191, ¶ 25). Corephotonics agreed, at least with respect to the term "light weight." *See* Appx421. Specifically, Corephotonics argued that there is "no standard definition of 'lightweight' in the field of camera design" and that "the question of whether something is lightweight is a 'relative' question, which depends on the 'application' and on what other designs are available for use in that application." Appx421 (Sur-reply) (citing Appx3852, 122:4–11, 122:4–18 (Sasián's Deposition)). Thus, there is no dispute that the reference to "light weight" electronic zoom in Golan is relative.

The Board, however, erred in determining what Golan's reference to "light weight" is relative *to*. Appx34. When read in context, there can be no dispute as to this issue. *See* Appx1206, ¶ 8. Golan's reference to "light weight electronic zoom" is found in the inventor's statement of the present invention's solution to the previously identified problems in the art. Appx1206, ¶¶ 8–9. The problems in the art identified by the inventor of Golan were related to traditional optical zoom lenses. *See* Appx1206, ¶ 7 (comparing electronic zoom to optical zoom). Accordingly, when viewed in context, the relative comparison in Golan is clear: heavy optical zoom

lenses versus Golan's dual-lens system with lossless electronic zoom. *See* Appx1206, ¶¶ 7–9; *see also* Appx397–398 (Reply), Appx2190–2191, ¶¶ 23–25.

In response to Corephotonics' arguments regarding Golan's reference to "light weight," Apple presented exemplary evidence of a "heavy and expensive" traditional optical zoom lens with comparable focal length, known as a Fujinon A36X14.5 lens. Appx2190–2191, ¶ 23 (discussing Appx3024–3025), Appx333–335, Appx346–347 (Resp.). Apple's expert explained that the Fujinon A36X14.5 lens weighed approximately 10 pounds and had a length of approximately 14.3 inches. Appx2190–2191, ¶ 23. Apple's evidence regarding the Fujinon A36X14.5 lens was the *only* example in evidence indicating the approximate weight of an optical zoom lens. *See* Appx396 (discussing 36x zoom range for Fujinon A36X14.5 lens, citing Appx3024 (Fujinon lens), Appx2190–2191, ¶ 23), Appx398 (discussing 36x zoom range for Golan-Kawamura combination, citing Appx2192, ¶ 27), Appx219 (Petition discussing Golan's lossless zoom range of 36 using Wide and Tele images and citing Appx1163–1164, ¶ 123, Appx1206, ¶¶ 7, 9). Accordingly, in that correct context, Kawamura's lens (approximately 7 inches in length) is, indeed, lighter than a comparable optical zoom lens such as the Fujinon A36X14.5. And when Kawamura's lens is then used in Golan's system, Golan's system achieves its goal of providing a

light weight zoom camera system—significantly lighter than a traditional optical zoom lens like the Fujinon A36X14.5.

Despite the straightforward problem and solution identified in Golan, which provides the *only* context in Golan for the relative terms "heavy" and "light weight," the Board concluded that "the record does not support a finding that a POSITA would have understood these terms to be relative to a lens assembly of the size taught by Kawamura or of the size of the Fujinon lens." Appx34. Instead, the Board "determine[d] that a POSITA would have understood these terms to be relative to what is disclosed in Golan, which is a miniature digital camera, and correspondingly-sized image sensors (e.g., 1/4″ or 1/3″ miniature digital sensors)." Appx34. But those findings are unsupportable in light of Golan's disclosure.

As discussed above, the Board erred by viewing Golan as being limited to miniature camera systems. *See supra* Section I. That alone is a sufficient basis for also overturning the Board's findings regarding the relative terms "heavy" and "light weight," which are based on that same faulty premise. Similarly, the Board's later conclusion that there was insufficient evidence to show that a POSITA would have viewed Kawamura's lens as "light weight" was based on that same faulty assumption that Golan applies only to miniature cameras. *See* Appx35.

Regardless of whether Golan's system is viewed as being generally applicable beyond the context of miniature cameras, the evidence the Board cited does not support its finding that Golan's reference to "light weight" should be with reference to a miniature camera.

The Board cited just two pieces of evidence to support its understanding of Golan's use of the relative term "light weight." Appx34 (citing Appx1206, ¶ 4 and Appx3243–3244, ¶ 54). The citation to Golan's paragraph 4 merely pertains to the same 5-megapixel example which, as discussed above, is addressing the mathematical understanding of lossless zoom; it does not compare the weights of anything. Appx1206, ¶ 4. In fact, the Board elsewhere in its decision found an "absence of any size or weight-related information for comparison in Golan," further confirming that Golan's reference to a 5-megapixel image sensor was not intended to be a benchmark for size or weight comparisons. *See* Appx35. The Board's citation to the testimony of Corephotonics' expert is similarly unhelpful, as it primarily pertains to the corresponding size of a 5-megapixel sensor and only addresses the term "light weight" in conclusory fashion. Appx3243–3244, ¶ 54 (stating, without any citation, that "a POSITA reading Golan would recognize that its 'light weight' and low cost electronic zoom invention contemplates the use of miniature camera modules"); *see also TQ Delta, LLC v. CISCO Sys., Inc.*, 942 F.3d

1352, 1358 (Fed. Cir. 2019) ("Conclusory expert testimony does not qualify as substantial evidence."). Thus, no evidence supports the Board's finding that "a POSITA would have understood these terms to be relative to what is disclosed in Golan, which is a miniature digital camera, and correspondingly-sized image sensors (e.g., 1/4″ or 1/3″ miniature digital sensors)." Appx34. The only comparisons made in Golan are between traditional optical zoom lenses and Golan's dual-lens system with lossless electronic zoom, so a reasonable fact-finder would have been compelled to conclude that Golan's reference to "light weight" is relative to optical zoom lenses.

With the correct relative comparison in place, the record evidence leads to just one conclusion: Kawamura's lens was, indeed, relatively "light weight" compared to traditional optical zoom lenses that Golan sought to avoid. This demonstrates that Apple's primary reason for combining Golan and Kawamura made perfect sense. Both references shared the same goal of providing compact imaging systems with good image performance. Thus, a POSITA would have been motivated to look to Kawamura's telephoto lens due to that shared goal, even if Kawamura would not have presented the *best* or absolute *lightest* option for minimizing weight. *See Intel Corp. v. Qualcomm Inc.*, 21 F.4th 784, 800 (Fed. Cir. 2021) ("It's not necessary to show that a combination is 'the *best* option, only that it

be a *suitable* option.'" (emphasis original) (quoting *PAR Pharm.*, 773 F.3d at 1197–98)).

Apple identified this error on rehearing, but the Board maintained its erroneous reasoning and newly faulted Apple for not discussing the Fujinon example in its Petition. *See* Appx60–61. But Apple's evidence regarding the Fujinon lens was directly responsive to Corephotonics' arguments, and Corephotonics had an opportunity to address that evidence in its Sur-reply, including with new deposition testimony. *See* Appx425–426 (Sur-reply); *see also VidStream LLC v. Twitter, Inc.*, 981 F.3d 1060, 1065 (Fed. Cir. 2020) (permitting responsive evidence).

Given that the Board's findings regarding Golan's use of the terms "heavy," "expensive," and "light weight" lack any evidentiary support—and are in fact directly contrary to the only comparison disclosed in Golan (the contemplated improvement over traditional optical zoom lenses)—the Court should reverse the Board's analysis as to this issue and hold that the shared goals of the two references demonstrates a reason to combine the references. Alternatively, the Court should at least reverse the findings as to this issue and remand for the Board to reevaluate Apple's obviousness arguments under a correct understanding of the prior art.

III. The Board failed adequately to address Apple's grounds supporting the combination of Golan and Kawamura.

The Board's Decision should be vacated and remanded for further analysis for an additional reason. "[T]here is no rule that a single reference that teaches away will mandate a finding of nonobviousness." *Adapt Pharma Operations Ltd. v. Teva Pharms. USA, Inc.*, 25 F.4th 1354, 1371 (Fed. Cir. 2022) (quoting and approving of the district court's reasoning). Rather, obviousness must be determined by consideration of the prior art "*as a whole* for what it teaches." *Medichem, S.A. v. Rolabo, S.L.*, 437 F.3d 1157, 1166 (Fed. Cir. 2006); *see also Adapt Pharma Operations*, 25 F.4th at 1372 (the fact finder is "entitled to consider the teachings of the prior art as a whole in finding that the prior art did not teach away from the claimed invention"). In narrowly focusing on the perceived size limitations of Golan, the Board failed to consider the prior art as a whole or Apple's arguments and evidence based on that art. Indeed, the Final Written Decision scarcely mentions Apple's actual stated reasons for combining Golan and Kawamura other than to summarily dismiss them as "insufficient." Appx37 (citing Appx187–189 (Pet.)). But relative size of the prior art was not the basis of Apple's proposed combination, and the Board erred in failing to give Apple's stated motivations adequate consideration.

To prove obviousness, "it can be important to identify a reason that would have prompted a person of ordinary skill in the relevant field to combine the elements

in the way the claimed new invention does." *KSR Int'l Co. v. Teleflex Inc.*, 550 U.S. 398, 418 (2007). "Any motivation, 'whether articulated in the references themselves or supported by evidence of the knowledge of a skilled artisan, is sufficient.'" *Bayer Pharma AG v. Watson Labs, Inc.*, 874 F.3d 1316, 1324 (Fed. Cir. 2017) (quoting *Outdry Techs. Corp. v. Geox S.p.A.*, 859 F.3d 1364, 1370–71 (Fed. Cir. 2017)). Evidence of a reason to combine prior art references may be found in numerous ways, including, for instance, "explicitly or implicitly in market forces; design incentives; the interrelated teachings of multiple patents; any need or problem known in the field of endeavor at the time of invention and addressed by the patent; and the background, knowledge, creativity, and common sense of the person of ordinary skill." *Plantronics, Inc. v. Aliph, Inc.*, 724 F.3d 1343, 1354 (Fed. Cir. 2013) (internal quotations omitted). Moreover, a proposed combination need not be the best, "preferred, or the most desirable combination described in the prior art in order to provide motivation" to combine, but rather need only be a suitable option. *In re Fulton*, 391 F.3d 1195, 1200 (Fed. Cir. 2004); *PAR Pharm., Inc. v. TWI Pharm., Inc.*, 773 F.3d 1186, 1196–97 (Fed. Cir. 2014).

Here, Apple identified multiple reasons to combine Golan and Kawamura. *First*, a "POSITA would have been motivated to apply Kawamura's teachings of a telephoto lens including five lens elements in the digital camera of Golan to produce

the obvious, beneficial and predictable results of a digital camera including a tele lens with a compactness of an overall length while having an excellent image-formation performance as taught by Kawamura." Appx187 (citing Appx1132–1134, ¶¶ 60–64 (Sasián Decl.)). Apple reasoned that "[b]ecause Golan does not provide specific lens prescriptions, a POSITA would have had the need of using a tele lens," and a "POSITA would have been motivated to apply Kawamura's teachings of tele lens because of the imaging benefits and compactness of an overall length with excellent image-formation performance as taught by Kawamura." Appx187 (citing Appx1132, ¶ 60 (Sasián Decl.)).

Second, Apple explained that Golan and Kawamura are analogous art in the same field of endeavor pertaining to imaging systems including a telephoto lens that share the same goal of addressing deficiencies in optical lenses. Appx187 (citing Appx1133, ¶ 61 (Sasián Decl.)). And, a "POSITA would have been motivated to incorporate the teachings of Golan and Kawamura because they share a need to provide a compact and light weight imaging system while providing excellent image qua[lity]." Appx188 (citing Appx1133–1134, ¶ 62 (Sasián Decl.)); *see also* Appx1206, ¶¶ 7–8. These goals are consistent with those in the '408 patent, which seeks to achieve a "thin digital cameras with optical zoom operating in both video and still mode" while avoiding threats to image quality such as through "parallax artifacts

when moving to the Tele camera in video mode." Appx78, 2:31–34, 2:49–51; *see also* Appx79, 3:22–25. Such overlapping recognition of the problem to be solved supports a finding that a POSITA would have been motivated to combine the references. *See Adapt Pharma Operations*, 25 F.4th at 1365–66 (finding acknowledgement of the same problem to be solved as articulated in the invention as evidence of motivation to combine). But here, the shared goal between the prior art and the claimed invention is not the only basis for a motivation to combine.

Third, Apple also showed a POSITA would have recognized additional benefits from Kawamura's telephoto lens, including "a relatively large field of view and little vignetting." Appx188 (citing Appx1133–1134, ¶ 62 (Sasián Decl.)). And Apple concluded that "providing a compact and light weight imaging system with excellent image performance is a need or a goal shared by Golan and Kawamura and provides at least one reason to combine the respective teachings." Appx189 (citing Appx1133–34, ¶ 62 (Sasián Decl.)).

Finally, Apple showed that "combining the teachings of Kawamura with the system of Golan would have produced operable results that are predictable." Appx189 (citing Appx1134–35, ¶ 63 (Sasián Decl.)). Specifically, Apple explained that "combining Kawamura's teachings of telephoto lens design in the digital camera of Golan" would have been as simple as "modifying the tele lens 120 in zoom

control subsystem of Golan according to Kawamura's teachings," resulting in "the benefits of a compact imaging system with excellent image performance" as described by Kawamura. Appx1135, ¶ 63 (Sasián Decl.).

Although the Board repeated Apple's articulated bases for combining Golan and Kawamura (*see* Appx19–20), it did not squarely address those grounds, choosing instead to focus on "responsive" contentions in Apple's Reply. *Compare* Appx19–20 (summarizing Apple's bases for combining Golan and Kawamura), *with* Appx25–35 (addressing, *e.g.*, whether Golan's teachings apply to larger imaging systems). The Board failed to address the evidence showing a POSITA would have been motivated to look to Kawamura for the added benefits of little vignetting and a relatively larger field of view. *See* Appx188 (Pet.). It also failed to address Apple's explanation that "[b]ecause Golan does not provide specific lens prescriptions, a POSITA would have had the need of using a tele lens" like that taught by Kawamura. *See* Appx187 (citing Appx1132, ¶ 60 (Sasián Decl.)).

The Final Written Decision mentions Apple's argument that the combination would yield predictable results only to describe the argument as "too generic" and not adequately explained. Appx37. But that ignores Apple's explanation (supported by Dr. Sasián's testimony) that "combining Kawamura's teachings of telephoto lens design in the digital camera of Golan" would have been as simple as "modifying the

tele lens 120 in zoom control subsystem of Golan according to Kawamura's teachings," resulting in "the benefits of a compact imaging system with excellent image performance" as described by Kawamura. Appx1135, ¶ 63.[10]

To the extent the Board offers any analysis of Apple's arguments, it is tainted throughout by the overarching and erroneous presumption that Golan is narrowly limited to miniature camera technology and could not apply to any other device. *See, e.g.*, Appx 34 (finding "the 5 megapixel image sensor array is the only disclosure in Golan which might indicate to a POSITA what scale of lens assembly Golan's teachings would be applicable to"); *see also supra* Section I.

As to the original reasons in Apple's Petition for combining Golan and Kawamura—analogous art in the same field of endeavor, shared goals, maintenance of image quality, predictable results, the interrelated teachings of Golan and Kawamura that would render the combination desirable, and the added benefits deriving from Kawamura's relatively large field of view and little vignetting—the Final Written Decision dedicates little more than two pages that do no more than summarily dismiss the arguments as "insufficient" without adequate analysis or

---

[10] The Final Written Decision further rejects the notion that there were only a finite number of options available. Appx38. But Apple's Petition did not rest on the idea that there were only a finite number of options. Instead, Apple identified why a POSITA would have been motivated to look to the teachings of Golan and Kawamura.

explanation. *See, e.g.*, Appx37 (dismissing Apple's contention of predictable results as "too generic and not sufficiently explained or supported"), Appx37–39. And even then, the scant analysis rests primarily on the erroneous presumption that the size distinctions between the representative devices disclosed in Golan and Kawamura create an insurmountable hurdle to any other motivation. *See, e.g.*, Appx39 ("We are not persuaded for the same reason discussed above, *that in the absence of a comparison between two imaging systems of differing sizes in Golan*, the record supports a finding that 'lightweight' would have been understood to refer to a larger-scale imaging system capable of accommodating a lens assembly of the size disclosed in Kawamura." (emphasis added)).

The Board's failure to address the stated motivations to combine leaves Apple hard-pressed to respond and, at a minimum, supports a remand for proper consideration of and specific findings on those grounds under the proper legal standards without the taint of the presumption that Golan is limited to miniature devices. *See Donner Tech., LLC v. Pro Stage Gear, LLC*, 979 F.3d 1353, 1358 (Fed. Cir. 2020) ("The Board 'must make the necessary findings and have an adequate evidentiary basis for its findings.'") (quoting *In re NuVasive, Inc.*, 842 F.3d 1376, 1382 (Fed. Cir. 2016)); *see also Princeton Vanguard, LLC v. Frito-Lay N. Am., Inc.*, 786 F.3d 960, 970 (Fed. Cir. 2015) (although the "Board is not required to discuss

every piece of evidence," it cannot "disregard [evidence] without explanation" or "short-cut its consideration of the factual record before it").

Here, once the proper standard is applied and the Board's erroneous presumption that Golan may only be considered in the context of miniature devices is set aside, Apple's bases for combining Golan and Kawamura compel a finding of obviousness. *See Gen. Elec. Co. v. Raytheon Techs. Corp.*, 983 F.3d 1334, 1345–46 (Fed. Cir. 2020) (reversing Board's finding of non-obviousness and rendering judgment of obviousness).

CONCLUSION

For the reasons above, the Court should reverse the Board's Decision, hold that a POSITA would have been motivated to combine Golan and Kawamura based at least on their shared goals, hold claim 5 unpatentable as obvious, and remand for the Board to analyze the parties' arguments regarding claim 6, including an analysis of the parties' outstanding claim construction dispute surrounding the term "smooth transition." Alternatively, the Court should reverse, vacate, and remand for further proceedings as to both challenged claims.

Respectfully Submitted,

HAYNES AND BOONE, LLP

/s/ Debra J. McComas
Debra J. McComas
Andrew S. Ehmke
2323 Victory Avenue, Suite 700
Dallas, Texas 75219
Phone: (214) 651-5375
Fax: (214) 200-0525
Debbie.McComas@haynesboone.com
Andy.Ehmke@haynesboone.com

David W. O'Brien
Hong Shi
600 Congress Avenue
Suite 1300
Austin, Texas 78701
Phone: (512) 867-8457
Fax: (512) 867-8613
David.OBrien@haynesboone.com
Hong.Shi@haynesboone.com

Angela M. Oliver
800 17th Street NW, Suite 500
Washington, D.C. 20006
Phone: (202) 654-4552
Fax: (202) 654-4252
Angela.Oliver@haynesboone.com

Attorneys for Appellant Apple Inc.

CERTIFICATE OF COMPLIANCE

1. This brief complies with the type-volume limitation of Fed. Cir. R. 32(b)(1) because:

■ this brief contains **13,683** words, excluding the parts of the motion exempted by Fed. R. App. P. 32(f) and Fed. Cir. R. 32(b)(2).

2. This motion complies with the typeface and type style requirements of Fed. R. App. P. 32(a)(5) and 32(a)(6) because:

■ this brief has been prepared in a proportionally spaced typeface using Microsoft Word 2016 in 14-point Equity A font.

/s/ Debra J. McComas
Debra J. McComas

ADDENDUM

Tab	Document	Appx Pages
1	Final Written Decision in IPR2020-00489	Appx1 – Appx42
2	Decision Denying Request for Rehearing	Appx43 – Appx67
3	U.S. Patent No. 10,015,408	Appx68 – Appx84

Trials@uspto.gov
571-272-7822

Paper 32
Entered: July 26, 2021

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

APPLE INC.,
Petitioner,

v.

COREPHOTONICS, LTD.,
Patent Owner.

IPR2020-00489
Patent 10,015,408 B2

Before BRYAN F. MOORE, GREGG I. ANDERSON, and MONICA S. ULLAGADDI, *Administrative Patent Judges.*

ULLAGADDI, *Administrative Patent Judge.*

JUDGMENT
Final Written Decision
Determining No Challenged Claims Unpatentable
35 U.S.C. § 318(a)

I. INTRODUCTION

Apple Inc. ("Petitioner") filed a Petition to institute an *inter partes* review of claims 5 and 6 ("the challenged claims") of U.S. Patent No. 10,015,408 B2 (Ex. 1001, "the '408 patent"). Paper 2 ("Pet."). Corephotonics, Ltd. ("Patent Owner") filed a Preliminary Response. Paper 7 ("Prelim. Resp.").

We instituted an *inter partes* review of each of the challenged claims on the ground set forth in the Petition. Paper 8 ("Institution Decision" or "Inst. Dec."). Patent Owner filed a Patent Owner Response (Paper 13, "PO Resp."), and Petitioner filed a Petitioner Reply (Paper 18, "Pet. Reply"). Patent Owner thereafter filed a Sur-reply (Paper 20).

Oral arguments were heard on May 26, 2021, and a transcript has been entered into the record. Paper 31 ("Tr."). Petitioner objected to various slides in Patent Owner's demonstratives for the oral hearing (Paper 29) and Patent Owner similarly objected to various slides in Petitioner's demonstratives (Paper 30).

Petitioner has the burden of proving unpatentability of the challenged claims by a preponderance of the evidence. 35 U.S.C. § 316(e) (2018). Having reviewed the parties' arguments and supporting evidence, for the reasons discussed below, we determine that Petitioner has not demonstrated by a preponderance of the evidence that any of the challenged claims are unpatentable.

II. BACKGROUND

A. Related Proceedings

Petitioner and Patent Owner identify the following corresponding district court proceeding: *Corephotonics, Ltd. v. Apple Inc.*, Case No. 5:19-

cv-04809-LHK (N.D. Cal.). Pet. 1–2; Paper 6, 1.[1] Petitioner also notes the filing of a related *inter partes* review (IPR2020-00488) challenging claims 1–4 and 7 of the ’408 patent. Pet. 2. We did not institute trial in that proceeding. IPR2020-00488, Paper 9 (decision denying *inter partes* review).

B. The ’408 Patent

The ’408 patent issued from an application that is a continuation of U.S. Application No. 14/880,251, filed on October 11, 2015, which is a continuation of U.S. Application No. 14/365,711, which was filed on June 16, 2014, and matured into U.S. Patent No. 9,185,291. Ex. 1001, code (63). U.S. Application No. 14/365,711 is an application under 35 U.S.C. § 371 of international patent application PCT/IB2014/062180, filed on June 12, 2014, and claims priority to U.S. Provisional Application No. 61/834,486, filed on June 13, 2013. *Id.* at code (60), 1:7–16.

The ’408 patent concerns a dual-aperture zoom digital camera that operates in both still and video modes. *Id.* at code (57). The camera includes a Wide sub-camera and a Tele sub-camera, each of which includes a fixed focal length lens, an image sensor, and an image signal processor. *Id.* at 3:32–35. Figure 1A, reproduced below, illustrates a dual-aperture zoom imaging system, which is also referred to as a digital camera. *Id.* at 5:60–61, 6:18–20.

---

[1] Patent Owner cites *Corephotonics, Ltd. v. Apple Inc.*, Case No. **3**:19-cv-04809-LHK (N.D. Cal.) (Paper 6, 1), but this case number appears to reflect a typographical error. A PACER search of Case No. 5:19-cv-04809 reveals that Patent Owner’s complaint in that case was likewise erroneously identified as “Civil Action No. 3:19-cv-4809” on its cover page.

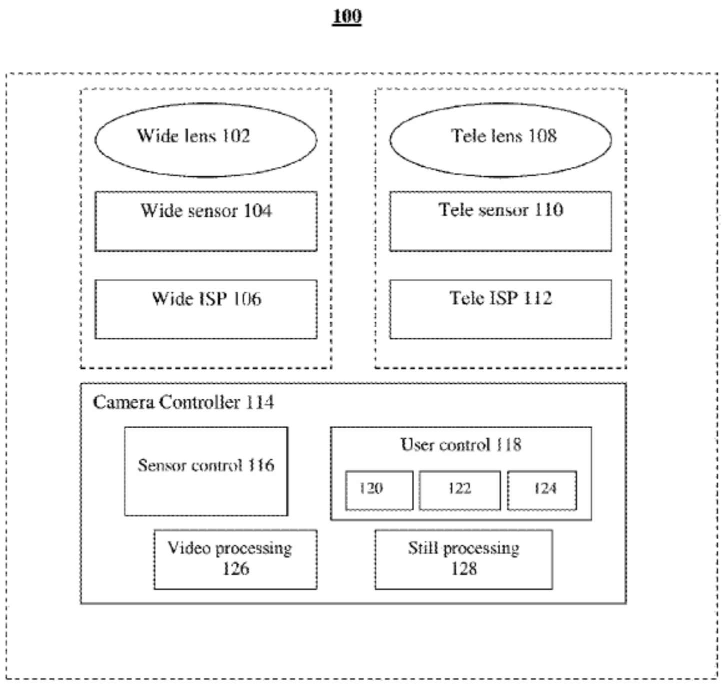


FIG. 1A

Figure 1A shows a dual-aperture zoom imaging system. *Id.*

In some embodiments, "the lenses are thin lenses with short optical paths of less than about 9mm" and "the thickness/effective focal length (EFL) ratio of the Tele lens is smaller than about 1." *Id.* at 3:39–41. These size specifications reflect the fact that "[h]ost device manufacturers prefer digital camera modules to be small, so that they can be incorporated into the host device without increasing its overall size." *Id.* at 1:31–33. An exemplary thin camera may use a lens block for the Tele lens, where the lens block may include five lens elements. *See id.* at 12:44–61. Figure 9, reproduced below, illustrates a lens block with first lens element 902 having positive power, second lens element 904 having negative power, third lens element 906 having positive power, fourth lens element 908 having negative power, and fifth lens element 910 having positive or negative power. *Id.* at 12:54–61.

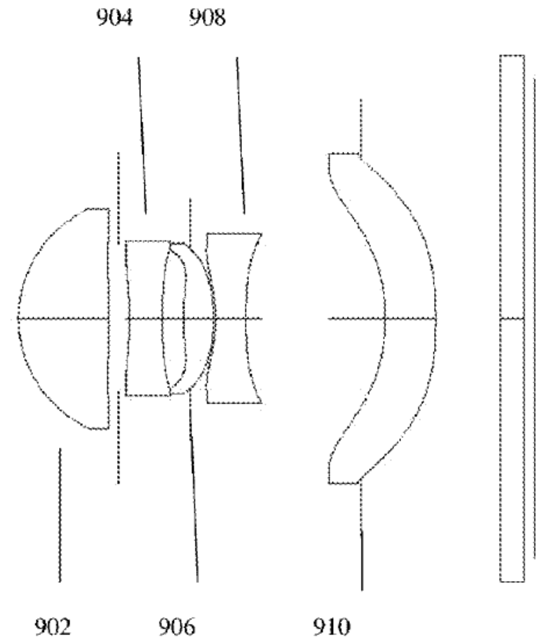


FIG. 9

Figure 9 shows a lens block in a thin camera. *Id.* at 6:12–13.

The ’408 patent discloses that in still mode, the camera performs zoom by either fully or partially fusing Wide and Tele images, where a fused image includes information from both Wide and Tele images. *Id.* at 3:44–49. In video mode, however, the camera performs optical zoom by switching between Wide and Tele images—i.e., without fusion—in order “to shorten computation time requirements, thus enabling high video rates.” *Id.* at 3:51–54. The invention uses the Wide sub-camera output for a low zoom factor (ZF) and the Tele sub-camera output for a high ZF. *Id.* at 11:13–29.

Normally, a user sees a jump, or discontinuous image change, when the camera switches between sub-camera output images. *Id.* at 10:37–39. The ’408 patent addresses this issue by employing a “smooth transition,” which “is a transition between cameras or [points of view] that minimizes the jump effect,” and which “may include matching the position, scale,

brightness and color of the output image before and after the transition." *Id.* at 10:39–45. Because "an entire image position matching between the sub-camera outputs is in many cases impossible," a smooth transition may achieve position matching "only in the [region of interest] while scale brightness and color are matched for the entire output image area." *Id.* at 10:45–52.

C. Challenged Claims

Petitioner challenges claims 5 and 6 of the '408 patent. Claim 5 is independent, and claim 6 depends from claim 5. Independent claim 5 is reproduced below.

> 5. A zoom digital camera comprising:
>
> a) a first imaging section that includes a fixed focal length first lens with a first field of view (FOV_1) and a first image sensor; and
>
> b) a second imaging section that includes a fixed focal length second lens with a second FOV (FOV2) that is narrower than FOV, and a second image sensor, wherein the second lens includes five lens elements along an optical axis starting from an object starting with a first lens element with positive power, wherein the five lens elements further include a second lens element with negative power, a fourth lens element with negative power and a fifth lens element, wherein a largest distance between consecutive lens elements along the optical axis is a distance between the fourth lens element and the fifth lens element, and wherein a ratio of a total track length (TTL) to effective focal length (EFL) of the second lens is smaller than 1.

Ex. 1001, 14:1–18.

D. Asserted Ground of Unpatentability

Petitioner challenges claims 5 and 6 as follows. *See* Pet. 11.

Claims Challenged	35 U.S.C. §	Reference(s)/Basis
5, 6	103	Golan[2], Kawamura[3, 4]

In support, Petitioner relies on the declaration of Dr. José Sasián (Ex. 1003).

III. ANALYSIS

A. Principles of Law

A claim is unpatentable under 35 U.S.C. § 103 if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. *KSR Int'l Co. v. Teleflex Inc.*, 550 U.S. 398, 406 (2007). The question of obviousness is resolved on the basis of underlying factual determinations, including: (1) the scope and content of the prior art; (2) any differences between the claimed subject matter and the prior art; (3) the level of skill in the art; and (4) objective evidence of nonobviousness, i.e., secondary considerations. *See Graham v. John Deere Co.*, 383 U.S. 1, 17–18 (1966).

"In an [*inter partes* review], the petitioner has the burden from the onset to show with particularity why the patent it challenges is

[2] U.S. Patent Application Publication No. 2012/0026366 A1, published Feb. 2, 2012 (Ex. 1005, "Golan").
[3] Japanese Patent Application Publication No. S58-62609, published Apr. 14, 1983 (Ex. 1007, "Kawamura").
[4] Petitioner asserts "Kawamura was published September 14, 2006, and issued December 20, 2011." Pet. 12. This appears to be a mistake because Kawamura is a published application—not an issued patent—with a publication date of April 14, 1983. Ex. 1007, codes (11), (12), (43).

unpatentable." *Harmonic Inc. v. Avid Tech., Inc.*, 815 F.3d 1356, 1363 (Fed. Cir. 2016) (citing 35 U.S.C. § 312(a)(3) (requiring *inter partes* review petitions to identify "with particularity . . . the evidence that supports the grounds for the challenge to each claim")). The burden of persuasion never shifts to Patent Owner. *See Dynamic Drinkware, LLC v. Nat'l Graphics, Inc.*, 800 F.3d 1375, 1378 (Fed. Cir. 2015) (citing *Tech. Licensing Corp. v. Videotek, Inc.*, 545 F.3d 1316, 1326–27 (Fed. Cir. 2008)) (discussing the burden of proof in an *inter partes* review). Furthermore, Petitioner cannot satisfy its burden of proving obviousness by employing "mere conclusory statements." *In re Magnum Oil Tools Int'l, Ltd.*, 829 F.3d 1364, 1380 (Fed. Cir. 2016).

B. Level of Ordinary Skill in the Art

Petitioner contends,

> a Person of Ordinary Skill in the Art ("POSITA") at the time of the claimed invention would have a bachelor's degree or the equivalent degree in electrical and/or computer engineering, physics, optical sciences or a related field and 2–3 years of experience in imaging systems including optics and image processing.

Pet. 8–9. Petitioner supports its contention with the testimony of Dr. Sasián. Ex. 1003 ¶ 20.

Patent Owner argues that "[a] person of ordinary skill in the art (POSITA) of the '408 patent, at the time of the effective filing date, would have possessed an undergraduate degree in optical engineering, electrical engineering, or physics, with the equivalent of three years of experience in optical design." PO Resp. 12–13. Patent Owner supports its contention with the testimony of Dr. Duncan Moore. Ex. 2003 ¶ 14. Patent Owner

further contends that "the effective filing date of the '408 patent is June 13, 2013," and that "Apple's expert Dr. Sasián appears to have applied the date of June 13, 2013 in his analysis of the level of ordinary skill as well." PO Resp. 13 (citing Ex. 1003 ¶ 19).

The parties do not appear to dispute the effective filing date of the challenged claims and each rely on June 13, 2013, the earliest claimed priority date of the '408 patent, as the effective filing date in making their respective arguments. Accordingly, we determine the level of ordinary skill in the art as of this date. However, if the '408 patent is not entitled to the filing date of the provisional application from which it claims priority and is, instead, entitled to a *later* date, this would not alter the conclusions rendered in this Decision.

Neither party argues that the level of ordinary skill is dispositive of any issue. Further, we do not discern significant differences between the parties' definitions. The conclusions rendered in this Decision do not turn on selecting a particular definition for the level of ordinary skill. We determine that the level of ordinary skill in the art proposed by Petitioner is consistent with the '408 patent and the asserted prior art and as such, we adopt and apply Petitioner's proposal.

C. Claim Construction

For *inter partes* reviews filed on or after November 13, 2018, we apply the same claim construction standard used by Article III federal courts and the International Trade Commission, both of which follow *Phillips v. AWH Corp.*, 415 F.3d 1303 (Fed. Cir. 2005) (en banc), and its progeny. *See* 37 C.F.R. § 42.100(b); Changes to the Claim Construction Standard for Interpreting Claims in Trial Proceedings Before the Patent Trial and Appeal

Board, 83 Fed. Reg. 51,340, 51,341 (Oct. 11, 2018). Accordingly, we construe each challenged claim of the ’408 patent to generally have “the ordinary and customary meaning of such claim as understood by one of ordinary skill in the art and the prosecution history pertaining to the patent.” 37 C.F.R. § 42.100(b).

Petitioner proposes a construction for one limitation, as discussed in detail below. Pet. 9–11. Patent Owner disagrees with Petitioner’s proposed construction, as further detailed below. *See* Prelim. Resp. 15–17; PO Resp. 13–16.

“smooth transition”

Dependent claim 6 recites “the camera controller configured to provide video output images with a smooth transition when switching between a lower zoom factor (ZF) value and a higher ZF value or vice versa.” Ex. 1001, 14:21–24.

Petitioner contends “a POSITA would have understood . . . ‘*smooth transition*’ to mean ‘transition with a reduced discontinuous image change,’ for example, a transition with a continuous image change.” Pet. 10 (citing Ex. 1003 ¶¶ 44–47). Petitioner asserts the Specification supports this proposed construction. *Id.* at 10–11. In our Institution Decision, we rejected Petitioner’s proposed construction and preliminarily concluded that “smooth transition” means “a transition between cameras or points of view that minimizes the jump effect.” Inst. Dec. 11. In its Petitioner Reply, Petitioner asserts that

> [i]n the context of claim 6 of the subject ’408 Patent, the language of “a transition between cameras or points of view” in the construction for “smooth transition” is redundant and unnecessary, because claim 6 itself provides “*a smooth transition when switching between a low zoom factor (ZF) value and a*

> *higher ZF value or vice versa*." Given the language of the claim, Petitioner's proposed construction is entirely consistent with that adopted in the Institution Decision, and Petitioner's analysis applies to either construction.

Pet. Reply 2 (citing Ex. 1001, 14:22–24; Ex. 1013 ¶¶ 4–5).

Patent Owner disputes Petitioner's proposed construction for "smooth transition." PO Resp. 13–16. Patent Owner contends that "the term 'smooth transition' should be construed as 'a transition that minimizes the jump effect such that there is no jump in the ROI region.'" *Id.* at 16 (citing Ex. 2003 ¶ 44). This is a shift from its position in its Preliminary Response in which Patent Owner contends that "'smooth transition' should be construed as it was for the '291 patent: 'a transition between cameras or POVs that minimizes the jump effect.'" Prelim. Resp. 17. We point out this contention from the Preliminary Response to highlight the fact that Patent Owner's earlier proposed construction was an agreed-to construction from a district court litigation for related U.S. Patent No. 9,185,291.[5] *See* Prelim. Resp. 15–17; Ex. 2001, 2 (Joint Claim Construction and Prehearing Statement).

Based on our review of the complete record developed at trial, we conclude that our resolution of Petitioner's asserted ground of unpatentability does not turn on the construction of "smooth transition" or any other claim term. *Infra* §§ III.D.3–III.D.4. As such, we need not expressly construe "smooth transition" or any other claim term to resolve the dispute between the parties, and therefore, we do not expressly define any claim term. *See Nidec Motor Corp. v. Zhongshan Broad Ocean Motor Co.*, 868 F.3d 1013, 1017 (Fed. Cir. 2017) (explaining that construction is needed

[5] The '408 patent claims priority to the '291 patent. *See* Ex. 1001, code (63).

only for terms that are in dispute, and only as necessary to resolve the controversy).

D. Obviousness over Golan and Kawamura

Petitioner contends that claims 5 and 6 are unpatentable as obvious under 35 U.S.C. § 103 over Golan and Kawamura. Pet. 13–56. For the reasons that follow, we determine that the evidence does not sufficiently support Petitioner's arguments, and thus Petitioner does not establish the unpatentability of claims 5 and 6 by a preponderance of the evidence.

1. Overview of Golan (Ex. 1005)

Golan concerns a "method for continuous electronic zoom in a computerized image acquisition system," in which the system has "a wide image acquisition device and a tele image acquisition device." Ex. 1005, code (57). By providing "multiple image devices each with a different fixed field of view (FOV)," Golan's system "facilitates a light weight electronic zoom with a large lossless zooming range." *Id.* ¶ 9. Golan's Figure 1, reproduced below, illustrates a zoom control sub-system for an image acquisition system. *Id.* ¶ 26.

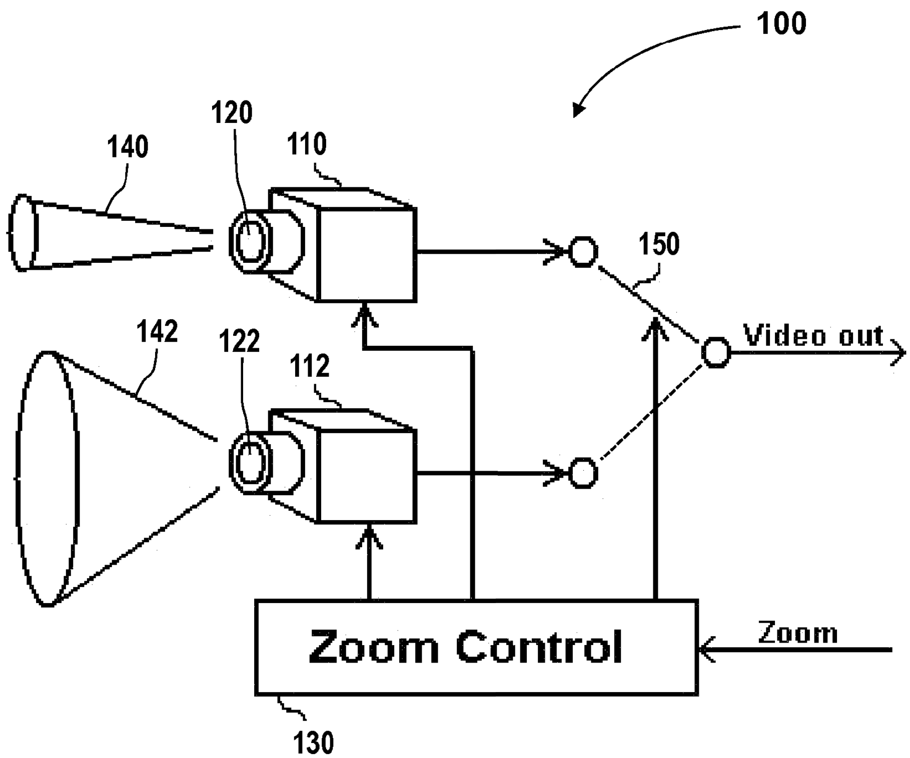


Fig 1

Figure 1 of Golan illustrates a zoom control sub-system for an image acquisition system. *Id.*

According to Golan, "[z]oom control sub-system 100 includes a tele image sensor 110 coupled with a narrow lens 120 having a predesigned FOV 140, a wide image sensor 112 coupled with a wide lens 122 having a predesigned FOV 142, a zoom control module 130 and an image sensor selector 150." *Id.* ¶ 37. The zoom control module 130 selects a relevant image sensor through image sensor selector 150 and calculates a relevant camera zoom factor when it receives a required zoom from an operator. *Id.* ¶ 39. Golan's system facilitates "continuous electronic zoom capabilities

with uninterrupted imaging," which "is also maintained when switching back and forth between adjacently disposed image sensors." *Id.* ¶ 40.

2. *Overview of Kawamura (Ex. 1007)*

Kawamura concerns a "Telephoto Lens." Ex. 1007, code (54). Kawamura's lens is a "medium telephoto lens" that has, "for example, a lens of a focal length of about 200 mm for a screen size of 6x7 or a focal length of about 150 mm for a screen size of 4.5x6." *Id.* at 1. The lens "keeps a compactness of an overall length to a conventional level of a telephoto ratio of about 0.96 to 0.88 but has an excellent image-formation performance due to favorably correcting spherical aberration of both a reference wavelength and color and also decreasing chromatic aberration in magnification." *Id.* Kawamura's Figure 1, reproduced below, illustrates one example of a lens system configuration. *Id.* at 5–6.

FIG. 1

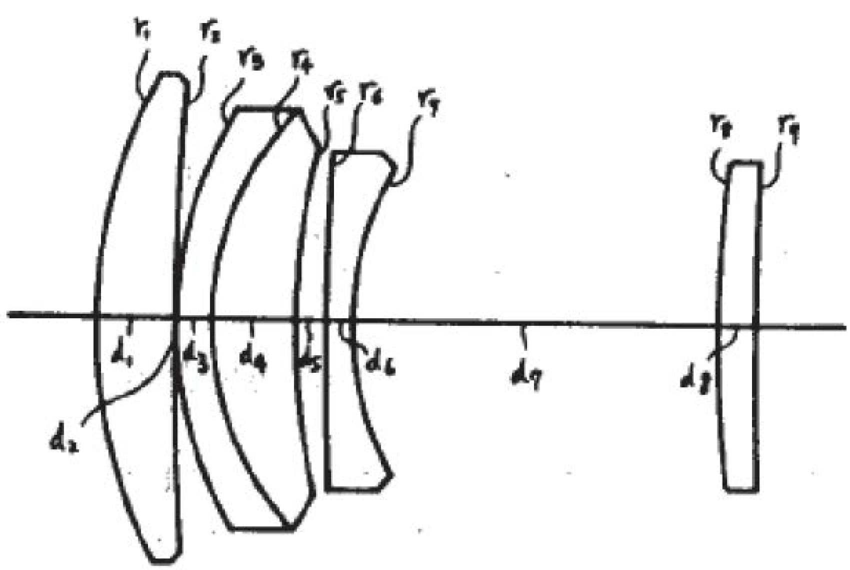


Figure 1 of Kawamura illustrates one example of a lens system configuration. *Id.*

According to Kawamura, the inventive lens, including the example shown in Figure 1, is

> a telephoto lens of a four-group, five-lens configuration of, in order from an object side, a first lens, which is a positive meniscus lens that is convex toward an object side; a second lens and a third lens, which are a laminated positive meniscus lens of a negative meniscus lens and a positive meniscus lens having a lamination surface that is convex toward the object side; a fourth lens, which is a negative lens having a rear surface with a large curvature that is concave toward an image-surface side; and a fifth lens, which is a positive lens.

Id. at 1–2.

3. Analysis of Independent Claim 5

Patent Owner does not contest Petitioner's showing that the combination of Golan and Kawamura teaches or suggests the following limitations of claim 5, but argues that Petitioner has failed to show that it would have been obvious to combine these references as set forth in the Petition. *See generally* PO Resp. We summarize Petitioner's contentions for each claim limitation to provide context for our findings and conclusion with respect to Petitioner's rationale for combining. As explained below, we agree with Patent Owner that Petitioner has failed to show that it would have been obvious to combine Golan and Kawamura.

a) Petitioner's Element-by-Element Contentions

"A zoom digital camera comprising:"

Petitioner contends that, to the extent the preamble of independent claim 5 is limiting, Golan teaches a zoom digital camera. Pet. 23. Specifically, Petitioner argues Golan's Figure 1 embodiment discloses zoom

control sub-system 100 that includes "a tele image sensor 110 coupled with a narrow lens 120 having a predesigned FOV 140, a wide image sensor 112 coupled with a wide lens 122 having a predesigned FOV 142, a zoom control module 130 and an image sensor selector 150." *Id.* at 24 (quoting Ex. 1005 ¶ 37) (emphasis omitted). Petitioner explains that "[i]n Golan's zoom control sub-system 100, each of the Wide imaging device (including wide image sensor 112 and wide lens 122) and the Tele imaging device (including tele image sensor 110 and narrow lens 120) defines an aperture for generating a corresponding digital image." *Id.* at 25 (citing Ex. 1003 ¶ 68). Accordingly, Petitioner asserts, "Golan's image acquisition system including a zoom control sub-system 100 is a digital camera providing digital zoom." *Id.*

"a first imaging section that includes a fixed focal length first lens with a first field of view (FOV_1) and a first image sensor"

Petitioner contends that Golan teaches the first imaging section of independent claim 5. Pet. 25–29. Specifically, Petitioner argues Golan discloses "a first imaging section that includes a wide lens 122 (first lens) with a FOV 142 (a first field of view (FOV_1)) and a wide image sensor 112 (first image sensor)." *Id.* at 25 (citing Ex. 1005 ¶¶ 36–37, Fig. 1). Petitioner asserts that Golan's wide lens 122 has a predesigned field of view that is fixed, and it is thus a fixed focal length lens. *See id.* at 26–29 (citing Ex. 1003 ¶¶ 72–73, 75–78; Ex. 1005 ¶¶ 9, 36–37, 43; Ex. 1016, 48).

> *"a second imaging section that includes a fixed focal length second lens with a second FOV (FOV2) that is narrower than FOV, and a second image sensor"*

Petitioner contends that Golan teaches the second imaging section of independent claim 5. Pet. 30–32. Specifically, Petitioner argues Golan discloses "a second imaging section that includes a tele image sensor 110 (second sensor) coupled with a narrow lens 120 (a fixed focal length second lens) having a predesigned FOV 140 (second FOV (FOV_2))." *Id.* at 30 (citing Ex. 1003 ¶ 79; Ex. 1005 ¶¶ 36–37, Abstract, Fig. 1). For reasons similar to those discussed with respect to Golan's wide lens 122, Petitioner asserts Golan's narrow lens 120, with a predesigned field of view, is a fixed focal length lens. *Id.* at 31 (citing Ex. 1003 ¶ 80; Ex. 1005 ¶¶ 9, 36–37, 43). Petitioner further asserts that Golan discloses "a FOV 140 (FOV_2) of the narrow lens 120 that is narrower than FOV 142 (FOV_1) of the wide lens 122." *Id.* (citing Ex. 1003 ¶ 81). In particular, Petitioner points to Golan's disclosure that "[p]referably, wide FOV 142 is substantially wider than narrow FOV 140." *Id.* (quoting Ex. 1005 ¶ 43) (emphasis omitted).

> *"wherein the second lens includes five lens elements along an optical axis starting from an object starting with a first lens element with positive power, wherein the five lens elements further include a second lens element with negative power, a fourth lens element with negative power and a fifth lens element"*

Petitioner contends that the combination of Golan and Kawamura renders obvious the lens element arrangement of the second lens of independent claim 5. Pet. 32–37. Specifically, Petitioner argues that Kawamura discloses a number of examples of a fixed focal length tele lens

having five lens elements as arranged in the claim. *Id.* at 33 (citing Ex. 1003 ¶ 84). Petitioner asserts Kawamura's Figure 1 shows five lens elements, which Petitioner labels L1–L5, where L1 is a positive meniscus lens; L2 and L3 are respective negative and positive meniscus lenses and are combined to form a laminated positive meniscus lens; L4 is a negative lens; and L5 is a positive lens. *Id.* at 33–36 (citing Ex. 1003 ¶¶ 85–89; Ex. 1007, 1, 5, Fig. 1).

> *"wherein a largest distance between consecutive lens elements along the optical axis is a distance between the fourth lens element and the fifth lens element" and*
>
> *"wherein a ratio of a total track length (TTL) to effective focal length (EFL) of the second lens is smaller than 1"*

Petitioner contends the combination of Golan and Kawamura renders obvious the independent claim 5 feature of a largest distance between consecutive lens elements being between the fourth and five lens elements. Pet. 37–41. Petitioner argues that Kawamura's Figure 1 shows that the distance d7 between the lenses Petitioner labels as L4 and L5 is the largest distance among all the respective distances between consecutive lenses in Figure 1. *Id.* at 38–40 (citing Ex. 1003 ¶¶ 95–97; Ex. 1007, 3).

Petitioner further contends that the combination of Golan and Kawamura renders obvious the total track length to effective focal length ratio feature of independent claim 5. *Id.* at 41–44. Petitioner argues that "Kawamura's telephoto lens 'keeps a compactness of an overall length to a conventional level of a telephoto ratio of about 0.96 to 0.88."'" *Id.* at 41 (quoting Ex. 1007, 1) (citing Ex. 1003 ¶ 103). Petitioner further argues that "[a] POSITA would have understood that a telephoto ratio of Kawamura is a

ratio of total track length (TTL)/effective focal length (EFL)." *Id.* (citing Ex. 1003 ¶ 103; Ex. 1006, 169).

b) Rationale for Combining Golan and Kawamura

Petitioner presents two alternative theories—a first alternative theory in which scaling is not involved in the combination of Golan and Kawamura and a second alternative theory in which the combination involves scaling. *See* Pet. 20–23.

(1) Petitioner's Contentions in the Petition Regarding its First Alternative Theory

Petitioner contends that a person of ordinary skill in the art would have been motivated to apply Kawamura's teachings to Golan "to produce the obvious, beneficial, and predictable results of a digital camera including a tele lens with a compactness of an overall length while having an excellent image-formation performance as taught by Kawamura." Pet. 20 (citing Ex. 1003 ¶¶ 60–64). Petitioner supports its contention by arguing that "Golan recognizes that a typical camera with a large dynamic zoom range 'requires heavy and expensive lenses, as well as complex design,' and has a goal to provide an imaging device with 'light weight' electronic zoom." *Id.* at 21 (quoting Ex. 1005 ¶¶ 7–8). Petitioner further contends that "Golan recognizes the need to provide excellent image quality by providing 'lossless electronic zoom' for maintaining the desired resolution and by providing 'continuous electronic zoom with uninterrupted imaging.'" *Id.* (quoting Ex. 1005 ¶ 4, Abstract) (citing Ex. 1003 ¶ 62). Petitioner also contends that Kawamura addresses these needs identified in Golan by providing "a telephoto lens that 'keeps a compactness of an overall length to a conventional level of a telephoto ratio of about 0.96 to 0.88 but has an

excellent image-formation performance.'" *Id.* (quoting Ex. 1007, 1) (citing Ex. 1003 ¶ 62) (emphases omitted). The resulting system, Petitioner argues, "would have been no more than the combination of known elements according to known methods (such as modifying the tele lens 120 in [the] zoom control subsystem of Golan according to Kawamura's teachings). . . ." *Id.* at 22. Dr. Sasián testifies that "combining the teachings of Kawamura with the system of Golan would have produced operable results that are predictable." Ex. 1003 ¶ 63.

(2) Petitioner's Contentions in the Petition Regarding its Second Alternative Theory

Petitioner alternatively contends that "[t]o the extent that modifications would have been needed in order to accommodate the teachings of Kawamura in the system of Golan," "a POSITA would have scaled the Kawamura lens prescriptions to fit into a digital camera of Golan . . . ." Pet. 22–23. Specifically, Dr. Sasián testifies that "lens scaling was a well-known practice in lens design, and a POSITA would have scaled the Kawamura lens prescriptions to fit into a digital camera of Golan while maintaining the compactness and an excellent image-formation performance." Ex. 1003 ¶ 64 (citing Ex. 1006, 57; Ex. 1009, 254–355). The cited evidence includes "Modern Lens Design: A Resource Manual," by Warren J. Smith (Ex. 1006), and "ZEMAX Optical Design Program User's Manual" (Ex. 1009). *See* Ex. 1006, 57 (discussing how "[a] lens prescription can be scaled to any desired focal length simply by multiplying all of its dimensions by the same constant" and that "[a]ll of the *linear* aberration measures will then be scaled by the same factor"); Ex. 1009, 254–255 (with respect to "scale lens," stating that "scale will scale the entire lens

by the specified factor," and that "[t]his useful for scaling an existing design to a new focal length, for example.").

c) Patent Owner Contentions Regarding Petitioner's Rationale for Combining

Patent Owner contends that a person of ordinary skill in the art would not have been motivated to combine Golan and Kawamura. PO Resp. 32–53.

With respect to Petitioner's first alternative theory that combining Golan and Kawamura does not require scaling, Patent Owner argues "the goal in Golan was to avoid 'heavy and expensive lenses' and to achieve 'light weight electronic zoom.'" *Id.* at 32 (Ex. 1005 ¶¶ 7–9). Patent Owner further contends that, "[i]n the context of camera design, the 7-inch Kawamura lenses would have been considered 'heavy,' both in 1981 when Kawamura was filed and in 2009 on Golan's asserted priority date."[6] *Id.* (Ex. 2003 ¶ 74). Patent Owner bases its position on "the fact that Golan contemplates use of 5 megapixel digital sensors," which it asserts "commonly had dimensions of 2.7 mm x 3.6 mm or 3.6 mm x 4.8 mm, [which are] much smaller than the 56 mm x 67 mm film size Kawamura's lenses were designed for." *Id.* at 33 (citing Ex. 2003 ¶ 75; Ex. 2007, 4).

---

[6] Patent Owner's reference to 2009 as the relevant time frame for the obviousness analysis appears to be in error. The face of the '408 patent shows a provisional application filed on June 13, 2013. Ex. 1001, code (60); *compare id.*, *with* Ex. 2003, 15 (Dr. Moore relying on June 13, 2013, as the effective filing date). As explained above, we do not expressly determine the priority date for the '408 patent to render the conclusions in this Decision. We rely on June 13, 2013, as the earliest *possible* priority date for the '408 patent.

With respect to Petitioner's second alternative theory that the combination of Golan and Kawamura involves scaling Kawamura's lens assembly, Patent Owner contends that "scaling [a lens] design will also scale the aberrations of the design and leave many dimensionless properties of the lens design unchanged[;] that does not does not mean that the resulting design will be practical or useful." *Id.* at 34–35 (citing Ex. 2003 ¶ 78). Patent Owner supports its position in part with an article titled "Optical Analysis of Miniature Lenses with Curved Imaging Surfaces" co-authored by Dr. Sasián and his student Dmitry Reshidko, which discloses that "[a] traditional objective lens can not [sic] be simply scaled down as a lens solution due to fabrication constraints, materials['] properties, manufacturing process[es], light diffraction and geometrical aberrations." *Id.* at 35–36 (quoting Ex. 2008, 1). Patent Owner also points to the Ph.D. dissertation of Dr. Sasián's student Yufeng Yan, which according to Patent Owner discloses

> "that the design approaches and lens constructions are significantly different between a miniature camera lens and a conventional camera lens" and that "if the conventional camera lens was simply scaled down to the same focal length of the miniature lens, it would encounter many issues." Yan further explained: "[s]caling down a conventional camera lens requires spatial tolerances to scale down with the same ratio, which is about the factor of 7. This creates a huge problem on the tolerance budget of element and surface decenter."

PO Resp. 36–37 (quoting Ex. 2013, 79, 83).

Patent Owner also cites to a Society of Photo-optical Instrumentation Engineers (SPIE) article by Bareau et al., "The Optics of Miniature Digital Camera Modules" (Ex. 2012, "Bareau"). *Id.* at 37 (citing Ex. 2012, 1, 3). Bareau was cited in a textbook authored by Dr. Sasián, "Introduction to Lens Design" (Ex. 2006, 195), and relied upon by Petitioner in another

proceeding challenging another patent assigned to Patent Owner (IPR2018-01146, Ex. 1012) in which Dr. Sasián provided expert testimony. Bareau discloses that

> When designing a camera module lens, it is not always helpful to begin with a traditional larger-scale imaging lens. Scaling down such a lens will result in a system that is unmanufacturable. . . . For glass elements, the edge thicknesses will become too thin to be fabricated without chipping. To achieve a successful design we have to modify our lens forms and adjust the proportions of the elements.

Ex. 2012, 1.

d) Petitioner's Responsive Contentions Regarding its Reasons for Combining

First, Petitioner argues that Golan's teachings are not limited to miniature cameras or sensors such as those used in mobile devices and thus, would have been understood by a POSITA to "apply to imaging systems of various sizes using any suitable image sensors." Pet. Reply 8 (citing Ex. 1013 ¶ 16) (arguing Golan's teachings also "include applications for conventional digital still cameras and other commercial, industrial and security applications including air-born vehicles/drones applications"). In support of its position that Golan's teachings "do[] not establish a dimension limitation on either its imaging system or image sensors," Petitioner cites to products and patents of the inventors and the assignee of Golan, NextVision Stabilized Systems, Ltd. ("NextVision"), that purportedly "confirm" "the applicability of Golan's teachings to applications beyond the mobile device realm." Pet. Reply 8.

Second, Petitioner argues that

> Patent Owner's arguments should be rejected because they improperly rely on Golan's example 5-Megapixel image sensor

> as a requirement, because they fail to recognize that a POSITA would have used other sensors (e.g., of different megapixel number or different dimensions) in Golan's systems, and because scaling to accommodate a sensor size was practical and with the skill of a POSITA, as demonstrated by Dr. Sasián.

Id. at 10 (citing Ex. 1013 ¶ 18). Petitioner further characterizes Patent Owner's expert's testimony as "admit[ting] that lightweight cameras may be used in applications including drones, endoscope applications, and space applications, without using miniature lenses as defined in the context of cellphone." *Id.* at 13 (citing Ex. 1017, 143:16–145:19, 148:16–19).

Third, Petitioner argues that a "POSITA would have understood that, in Golan, the terms 'heavy,' 'expensive,' and 'light weight' are relative." *Id.* at 13 (citing Ex. 1013 ¶ 25). Petitioner explains that

> Golan describes that a camera with a single optical zoom lens having a large dynamic zoom range typically requires "heavy and expensive lenses." An example of such a heavy and expensive lens is a Fujinon A36X14.5 lens, an optical zoom lens providing a zoom ratio of 36x. The Fujinon A36X14.5 lens is heavy with a weight of 4.58kg (about 10 pounds) and a length of 363.3 mm (about 14.3"), and is expensive (e.g., a used one priced on eBay for over $10,000).
>
> . . . .
>
> . . . [C]ompared to a camera with a single Fujinon A36X14.5 lens, according to Golan's teachings, a POSITA could and would have achieved light weight digital zoom of 36x by using a wide lens and a telephoto lens (e.g., based on Kawamura's lens design) that are cheaper and lighter than the Fujinon A36X14.5 lens. As such, Golan does not require using 1/4" or 1/3" miniature digital sensors to achieve a cheaper lightweight digital zoom.

Pet. Reply 12–13 (Ex. 1005 ¶ 7; Ex. 1028, 1; Ex. 1027, 1; Ex. 1013 ¶ 23).

Fourth, Petitioner contends that "Patent Owner's analysis is incorrect because it is based on a POSITA's understanding of technology in 1981 and incorrect understanding of ongoing relevance of older lens designs." *Id.* at 20 (emphasis omitted). Petitioner characterizes Patent Owner's argument as "imply[ing] that designs from 1981 would be wholly outdated by 2013," and asserts that "lens designs remain relevant designs to a POSITA for many decades." *Id.* at 21 (citing Ex. 1013 ¶ 39; Ex. 1025, 359–366 (textbook titled "Modern Lens Design" from 2005 allegedly including example telephoto lens designs from 1950, 1977, and 1982)). Petitioner further argues that "[b]ecause Patent Owner incorrectly relies on a[] POSITA's knowledge of the technology in 1981, [Patent Owner] fails to consider the ongoing relevance of older lens designs with modern lens design, and fails to evaluate prior art as a POSITA at the time the invention was made . . . ." *Id.*

e) Analysis of Rationale for Combining

For the reasons that follow, we determine that Petitioner's rationale for combining Golan and Kawamura, under either its first alternative theory or its second alternative theory, is not supported by sufficient rational underpinning.

(1) Petitioner's First Alternative Theory Without Scaling

We are not persuaded that Petitioner's evidence sufficiently supports its rationale for combining Golan and Kawamura and a finding that one of ordinary skill in the art at the time of the earliest priority date *of the '408 patent* would have understood Kawamura's lens assembly to have "compactness of an overall length" such that Kawamura's lens assembly would have been understood to address the needs identified in Golan and its

"goal to provide an imaging device with '*light weight*' electronic zoom," as Petitioner contends. Pet. 20–21 (quoting Ex. 1005 ¶¶ 7–8; Ex. 1007, 1) (citing Ex. 1003 ¶¶ 60–64) (emphases added).

With regard to Petitioner's *first* argument, there is insufficient evidence of record to support the proposition that Golan's teachings are applicable to imaging systems that are of a scale larger than that of the miniature cameras and image sensors used in mobile devices. According to Petitioner, a "POSITA's understanding of the applicability of Golan's teachings to applications beyond the mobile device realm is confirmed by other disclosures from Golan's inventors and assignee, NextVision. . . ." Pet. Reply 8 (citing Ex. 1013 ¶ 17). Petitioner then cites exhibits and patents purporting to show products of the assignee of Golan, NextVision. Pet. Reply 8–9 (citing Exs. 1022, 1024, 1026, 1030, 1034, 1035). Dr. Sasián's testimony in paragraph 17 of his Reply Declaration also relies on these exhibits and patents. Ex. 1013 ¶ 17; *see id.* ¶¶ 21, 28 (citing Exs. 1029, 1031, 1032).

As an initial matter, the fact that the assignee of the Golan reference produces products having imaging systems of varying sizes does not, without more, suggest that Golan's teachings, specifically, are applicable to these products or vice versa.[7] *Cf. Abbott Labs. v. Dey, L.P.*, 287 F.3d 1097, 1104 (Fed. Cir. 2002) (finding the relationship between

[7] We do not discern that an assignee's products would be relevant to the scope of a patent that is not asserted to cover those products and does not discuss those products in its specification. *Cf. See Astrazeneca AB v. Mut. Pharm. Co.*, 384 F.3d 1333, 1340 (Fed. Cir. 2004) (discussing disavowal of claim scope through criticism of other products in the general summary or description of the invention).

two unrelated patents, although having common subject matter, a common inventor, and ***the same assignee***, "insufficient to render particular arguments made during prosecution of [one of the patents] equally applicable to the claims of [the other patent]"). In fact, these exhibits regarding NextVision's products do not sufficiently establish—either alone or in combination with Dr. Sasián's testimony—that a person of ordinary skill in the art would have understood from the exhibits that Golan's teachings apply to image sensors, imaging systems, and lens assemblies of all sizes.

Dr. Sasián's reliance on the exhibits is conclusory. *See, e.g.*, Ex. 1013 ¶¶ 16, 17, 21, 28. Dr. Sasián's testimony regarding the exhibits simply lists them, describes their subject matter, and concludes that they confirm "the applicability of Golan's teachings to applications other than only mobile devices . . . ." *Id.* ¶ 17. Below we provide a summary of the references relied on by Petitioner and Dr. Sasián in order to support our finding that none of the exhibits adequately support Petitioner's contentions and Dr. Sasián's testimony as to Golan and its purported applicability to image sensors, imaging systems, and lens assemblies of all sizes.

Exhibit 1022 is U.S. Patent No. 8,896,697 B2 to Golan et al. ("Golan '697") and is titled "Video Motion Compensation and Stabilization Gimbaled Imaging System." Ex. 1022, codes (76), (54). Golan '697 discloses as its field of invention "an imaging system, operatively mounted on an air-born vehicle, that can transmit high resolution images of a selected region of interest, whereas the images are continuously compensated for vehicle motion." *Id.* at 1:14–18.

Exhibit 1024 is an article titled "IAI [(Israel Aircraft Industries)] Unveils the Ghost – a Miniature UAV [(Unmanned Aerial Vehicle)] For

Special Operations" by Tamir Eshel dated August 8, 2011 ("Eshel"). It depicts "twin rotors [that] create adequate lift within a relatively small diameter (0.75 cm/2.46 ft), enabling the Ghost [UAV] to navigate safely near obstacles, enter through windows and hover inside built-up areas or penetrate dense vegetation." Ex. 1024, 1–2.

Exhibit 1026 is a screen capture of NextVision's website and product MicroCam-D, an aerial photography camera. Ex. 1026, 1. It describes MicroCam-D as being 4.6 ounces and capable of performing digital zoom. *Id.* at 2. It also includes images of other NextVision products such as drone detection cameras, optical emission cameras, and other aerial photography cameras. *Id.* at 3–5.

Exhibit 1029 is a product manual for Kodak's EasyShare V610 dual lens digital camera ("Kodak EasyShare") which Dr. Sasián cites to show that "[a] POSITA would have understood that image sensors of different dimensions, for example, a 1/2.5" sensor, may be used in Golan," and contends that Kodak EasyShare has "a dual lens digital camera to provide a 5.3-megapixel image." Ex. 1013 ¶ 21.

Exhibit 1030 is an article from a global news service, Unmanned Aircraft Systems (UAS) Vision, titled "Lightweight UAS Demand Accelerates Development of Lightweight Payloads." The article describes how the "near future . . . will see smaller payloads achieved within radar[,] laser[,] and thermal systems" on the order of less than 100 grams. Ex. 1030, 3. The article expresses that such developments "are causing a change in the operational concept of UAS." *Id.*

Exhibit 1031 is U.S. Patent No. 8,462,209 B2 to Sun and is titled "Dual-swath Imaging System" ("Sun"). It discloses "[a] portable, aerial,

dual-swath photogrammetric image system comprising twin nadir pointing CCD cameras for simultaneously acquiring twin adjacent digital images for merging into a large panorama." Ex. 1031, codes (54), (57). Sun further discloses "a first lens shift mount . . . for physically shifting [a] first large format optical lens" and "a second lens shift mount . . . for shifting the focal point of said second large format optical lens . . . ." *Id.* at 10:32–38, 10:47–54.

Exhibit 1032 is U.S. Patent No. 7,974,460 B2 to Elgersma and is titled "Method and System for Three-dimensional Obstacle Mapping for Navigation of Autonomous Vehicle" ("Elgersma"). Ex. 1032, code (54). Elgersma discloses "an autonomous vehicle with an image capturing device, and focusing the image capturing device at a predetermined number of different specified distances to capture an image at each of the specified distances." *Id.* at code (57). Dr. Sasián cites Sun and Elgersma in support of the testimony that "a POSITA would have used image sensors of various dimensions, including sensors with sizes similar to a film size of Kawamura, that are suitable for applications," specifically, unmanned aerial vehicles. Ex. 1013 ¶ 28 (citing Ex. 1031, 2:31–45; Ex. 1032, 1:10, 1:25–26).

Exhibit 1034 is a video capture showing navigation to and through NextVision's website as of September 2, 2012, using the Internet Archive's Wayback Machine. The video capture shows footage shot by NextVision's MicroCam-D product. The video appears to show the MicroCam-D camera zooming in on targets and is annotated with the caption "digital zoom" at various points, in particular, at approximately 1:45 minutes.

Exhibit 1035 is a screen capture of a profile for NextVision describing the company as privately owned and "focusing on development and

production of Electro-Optical stabilized payload and solid state digital cameras for day and night observation." Ex. 1035, 1. It describes NextVision's MicroCam-D product as the world's first sub 100-gram, gyro-stabilized payload. *Id.*

Petitioner does not point to any portion of these exhibits that mentions Golan or the invention described therein. *See generally* Pet. Reply. Nor does Petitioner point to evidence that sufficiently addresses the applicability of Golan's specific teachings to any particular product or imaging system described in the cited exhibits. *Id.* Dr. Sasián's Reply Declaration does not offer perspective or sufficient explanation as to how a POSITA would have understood these exhibits to support his testimony and conclusions. In particular, Petitioner does not show sufficiently that the imaging systems in *any* of these exhibits achieve "light weight electronic zoom" using "two fixed focal length lenses and 'two (or more) image sensors, having different fixed FOVs'" "with a large lossless zooming range," as Dr. Sasián testifies that Golan teaches. Ex. 1013 ¶ 24 (citing Ex. 1005 ¶ 9). Below, we explain why Dr. Sasián's testimony—which mostly touches on Golan '697 and MicroCam-D—is insufficient to support a finding that any alleged multiple image sensors in Golan '697 or alleged digital zoom capability in NextVision's MicroCam-D described in Exhibits 1026 and 1034 correspond to the specific device and method taught by Golan.

During his deposition, with respect to the disclosure of "a high resolution image sensor" and "a multi-megapixel CMOS" in Golan '697 (Ex. 1022), Dr. Sasián testified that the "optical zoom" in Golan '697 "could refer to either a single lens or two lenses" and cited its claim 27 as support for the proposition that Golan '697 discloses "one or more image sensor

arrays." Ex. 2015, 97:4–8, 98:18–99:10. However, Dr. Sasián stopped short of concluding that Golan '697 teaches "two fixed focal length lenses" and "two (or more) image sensors, having different FOVs" as he does with Golan (Ex. 1013 ¶ 24):

> MR. RUBIN: So would you agree that the Golan '697 patent, Exhibit 1022, never says to use sensors having different angles of view in order to provide a zoom?
>
> MS. SHI: Objection. Out of the scope of the declaration.
>
> DR. SASIÁN: Well, I cannot -- At this moment, I cannot find a mention of different fields of view.

Ex. 2015, 99:14–22. Accordingly, Dr. Sasián's testimony demonstrates that he has not affirmatively testified that Golan '697 teaches sensors having different FOVs, which the accompanying objection of Petitioner's counsel further supports. *Id.* Independent from this deposition testimony, a review of Dr. Sasián's Second Declaration confirms that Dr. Sasián did not testify on whether Golan '697 has different fields of view, and further, whether any exhibit has "light weight electronic zoom" using "two fixed focal length lenses and 'two (or more) image sensors, having different fixed FOVs'" "with a large lossless zooming range," as Dr. Sasián testifies that Golan teaches. *See generally* Ex. 1013; Ex. 1013 ¶ 24 (citing Ex. 1005 ¶ 9).

With respect to the exhibits describing NextVision's MicroCam-D product, Dr. Sasián testified that MicroCam-D "may include more than one camera as the specifications teach camera in plural, cameras." *Id.* at 93:2–5. Dr. Sasián further testified that he did not know whether MicroCam-D utilized a mechanical zoom, and consequently stopped short of determining that MicroCam-D includes "two fixed focal length lenses" and "two (or more) image sensors, having different FOVs" as he did with Golan. *Id.* at

95:2–11; *compare id. with*, Ex. 1013 ¶ 24. When asked about the specific relevance of MicroCam-D to Golan, Dr. Sasián testified as follows:

> MR. RUBIN: What does the MicroCam-D have to do with the Golan patent that you rely on as prior art in this IPR?
>
> DR. SASIÁN: Well, the point I'm bringing up is that there are applications where Golan's disclosure may be relevant, may be applicable. That is the point.

Ex. 2015, 91:6–11.

During his deposition, Dr. Sasián did not rule out using mechanically moving parts to achieve optical zoom in MicroCam-D, which is a subject of multiple exhibits cited by Petitioner. *Id.* at 94:15–95:10. We consider this inquiry relevant to whether Dr. Sasián testifies that any of the exhibits have "light weight electronic zoom" using "two fixed focal length lenses and 'two (or more) image sensors, having different fixed FOVs'" because mechanically moving parts are something Golan avoids with its two fixed focal length lenses having different fields of view. Ex. 1013 ¶ 24 (citing Ex. 1005 ¶ 9); 1005 ¶¶ 7–9. As Dr. Moore explains,

> Traditionally, zoom capability was provided using mechanical optical zooming, moving lens elements relative to each other to change the focal length, and thus the magnification of the lens. Mechanical optical zoom lenses are generally more expensive and larger than fixed focal length lenses. Another approach to zoom is digital zooming, where a digital processor provides a magnification effect by cropping the image from a fixed focal length lens and interpolating between the pixels to create "a magnified but lower-resolution image."
>
> An alternative to both mechanical and traditional digital zoom is described in the '408 patent. In the '408 patent, an improved digital zoom is provided using a "dual-aperture" configuration.

Ex. 2003 ¶¶ 28, 29 (citing Ex. 1001, 1:45–49; 1:54, 3:30–32). Even with respect to the exhibits disclosing digital zoom cited by Petitioner after our Institution Decision, the record does not sufficiently support a finding that there is any disclosure of two image sensors that have different fields of view with fixed focal length lenses. *See, e.g.*, Ex. 2015, 99:14–22. Petitioner also does not make any such representations in its Reply. *See generally* Pet. Reply.

For the reasons discussed above, and particularly with respect to the digital zoom capability of the MicroCam-D camera described in Exhibits 1026 and 1034, the record does not contain sufficient evidence to support a finding that this capability corresponds to the specific method taught by Golan. Nor does the record sufficiently establish that the digital zoom method taught by Golan would have been understood by a POSITA to be the only method—or even one of a few methods—conceivably applicable to MicroCam-D or any other imaging system described in the exhibits cited by Petitioner, to provide the asserted functionality. Petitioner does not explain adequately why we should interpret Golan based on extrinsic evidence that does not "link" the teachings of Golan with any NextVision product or invention. As discussed above, we find Petitioner's contentions and Dr. Sasián's testimony conclusory.

With regard to Petitioner's *second* responsive contention, Petitioner characterizes Patent Owner's argument as limiting the teachings of Golan to the disclosed 5 megapixel image sensor array. Pet. Reply 10–11. We do not agree with Petitioner's characterization of Patent Owner's argument. We understand Patent Owner's reference to the 5 megapixel image sensor array disclosed in Golan as providing the only context in the record for the scale

of device or device components to which Golan's teachings are applied. PO Resp. 8–9; Ex. 1005 ¶ 4. The disclosure of the 5 megapixel image sensor array in Golan supports the finding that Golan is at least applicable to miniature digital cameras and image sensors such as those used in mobile devices. Ex. 1005 ¶ 4. As discussed above, there is no disclosure or evidence that discloses that Golan's teachings are applicable to larger-scale imaging systems, nor is there evidence of record that sufficiently supports a finding that a POSITA would have understood Golan's teachings to be applicable to larger-scale imaging systems, such as those of the size able to accommodate a lens assembly of size disclosed in Kawamura.

With regard to Petitioner's *third* responsive contention that a "POSITA would have understood that, in Golan, the terms 'heavy,' 'expensive,' and 'light weight' are relative," the record does not support a finding that a POSITA would have understood these terms to be relative to a lens assembly of the size taught by Kawamura or of the size of the Fujinon lens. the 5 megapixel image sensor array is the only disclosure in Golan which might indicate to a POSITA what scale of lens assembly Golan's teachings would be applicable to. *Id.* Instead, we determine that a POSITA would have understood these terms to be relative to what is disclosed in Golan, which is a miniature digital camera, and correspondingly-sized image sensors (e.g., 1/4" or 1/3" miniature digital sensors). *See* Ex. 2003 54 (Dr. Moore testifying that a "POSITA . . . in 2013, would have understood that a 5 megapixel sensor was likely to be a 1/3-inch or 1/3-inch sensor . . . .)

With regard to Petitioner's *fourth* responsive contention that Patent Owner improperly discounts Kawamura's teachings as no longer relevant as of Golan's priority date because Patent Owner is relying on the level of skill

in the art as of Kawamura's priority date of 1981, we do not view Patent Owner's arguments in the same way. Petitioner is correct in that the relevant level of skill in the art is *not* the timeframe associated with Kawamura—what constitutes "lightweight" or "compact" must be evaluated through the eyes of a POSITA as of the priority date of the '408 patent. We understand Petitioner to take the position that Kawamura's lens assembly is lightweight compared to some other lens assemblies—like the nearly ten pound Fujinon A36X14.5 lens. As discussed above, even assuming, *arguendo*, that "lightweight" is a relative term, Petitioner does not present sufficient evidence that a POSITA at the time of the priority date of the '408 patent (which could be as early as June 13, 2013 (*see* Ex. 1001, code (60)) would have thought of Kawamura's 7-inch lens assembly as "lightweight" or "compact"—particularly in the absence of any size or weight-related information for comparison in Golan and Golan's disclosure of only a "5 megapixel image sensor array" (*see* Ex. 1005 ¶ 4).

(2) Petitioner's Second Alternative Theory with Scaling

We are not persuaded that Petitioner's evidence sufficiently supports its rationale for combining Golan and Kawamura and a finding that one of ordinary skill in the art at the time of the earliest priority date *of the '408 patent* would have understood Kawamura's lens assembly to be compact in length or that Kawamura's lens assembly would have been understood to address the needs identified in Golan and Golan's "goal to provide an imaging device with '*light weight*' electronic zoom," as Petitioner contends (*supra* §§ III.D.3.e.1), particularly if it would have been necessary to scale Kawamura's lens assembly in order to modify Golan's teachings in

Petitioner's proposed combination. Pet. 20–23 (quoting Ex. 1005 ¶¶ 7–8; Ex. 1007, 1) (citing Ex. 1003 ¶¶ 60–64) (emphasis added). We are further not persuaded that a "POSITA would have scaled the Kawamura lens prescriptions to fit into a digital camera of Golan while *maintaining the compactness* and an excellent image-formation performance." Ex. 1003 ¶ 64 (citing Ex. 1006, 57; Ex. 1009, 254–355) (emphasis added).

We credit the testimony of Dr. Moore that a person of ordinary skill in the art would not have been motivated to scale Kawamura for use in Golan. *See, e.g.*, PO Resp. 33–34 (citing Ex. 2003 ¶ 76). Dr. Moore's testimony is supported by the 28-year difference between the Golan and Kawamura inventions and the resulting improvement in performance over decades-earlier, high-quality lenses. *Id.* Dr. Moore also explains that the "Kawamura lens would need to be scaled down by a factor of around 14x to 20x in order provide the same field of view" as Golan. Ex. 2003 ¶ 77 (citing Ex. 2005, 47:24–48:3 (Dr. Moore testifying that Dr. Sasián agrees, in his deposition testimony, with a scaling factor of at least 10).

We also credit Dr. Moore's testimony that "[a] POSITA would not have been motivated to go beyond [the] rich literature of miniature lens designs and try scaling old lenses, designed for different purposes, with little reason to expect the result would be manufacturable." Ex. 2003 ¶ 87. Moreover, Patent Owner has impeached Dr. Sasián's testimony by pointing to positions he has accepted in the past that contradict his testimony in the present proceeding. For example, Dr. Sasián's testimony that the combination of Golan and Kawamura would have been understood to be scalable is contradicted by his article that states that a POSITA would have been dissuaded from scaling a conventional camera lens or traditional

objective lens due to "fabrication constraints, materials['] properties, manufacturing process[es], light diffraction and geometrical aberrations." Ex. 2008, 1. Neither Petitioner nor Dr. Sasián sufficiently explains the contradiction; *see also* Ex. 2013, 79, 83 (Dr. Sasián's student's Ph.D. dissertation discussing issues associated with scaling down a conventional lens and required spatial tolerances). Bareau, an article cited in one of Dr. Sasián's textbooks (Ex. 2006, 195), also discusses manufacturing and fabrication constraints with regard to scaling "a traditional larger-scale imaging lens." Ex. 2012, 1.

(3) Remainder of Petitioner's Reasons for Combining Golan and Kawamura

The remainder of Petitioner's reasons for combining are also insufficient to support a conclusion of obviousness. For example, Petitioner's contentions that Golan and Kawamura are analogous art, share a common objective, and would have produced operable results that are predictable are insufficient to support a conclusion of obviousness. Pet. 20–22 (arguing that "the references are analogous prior art and are in the same field of endeavor pertaining to imaging systems including a telephoto lens," that "they share a need to provide a compact and light weight imaging system while providing excellent image [quality]," and that the combination "would have been no more than the combination of known elements according to known methods").

Although yielding predictable results can, in some situations, sustain a conclusion of obviousness, Petitioner's contention of predictable results is too generic and not sufficiently explained or supported to sustain a conclusion of obviousness. *See In re Kahn*, 441 F.3d 977, 988 (Fed. Cir.

2006) ("[R]ejections on obviousness grounds cannot be sustained by mere conclusory statements; instead, there must be some articulated reasoning with some rational underpinning to support the legal conclusion of obviousness.").

During the hearing, Patent Owner's counsel noted that "you don't necessarily have to show that that combination would be best, but you do have to provide a motivation to combine with a particular reference." Tr. 44:5–10. We take this opportunity to clarify that we are not requiring Petitioner to point out why Kawamura teaches a better telephoto lens than that of the universe of other telephoto lens assemblies. Patent Owner contends—and Petitioner disputes—that there was a "sea" of telephoto lens patents as of the relevant timeframe. Whether or not there were a "sea" as Patent Owner contends, there were more than a small number of predictable solutions, which even Petitioner's declarant acknowledges. *See* Ex. 2015, 114:14–18 (Dr. Sasián's testimony acknowledging there were several, well-known "lens designs that were publicly known for telephoto and miniature cameras" during the relevant timeframe). We further note that there is insufficient evidence of record to support a finding that a POSITA would have understood that there were only a few options for telephoto lens designs from which to choose such that Kawamura's lens assembly would have been the "obvious" choice. *Cf. Procter & Gamble Co. v. Teva Pharm. USA, Inc.*, 566 F.3d 989, 996 (Fed. Cir. 2009) ("When a person of ordinary skill is faced with 'a finite number of identified, predictable solutions' to a problem and pursues 'the known options within his or her technical grasp,' the resulting discovery 'is likely the product not of innovation but of ordinary skill.'").

Petitioner argues that the term "conventional" in Kawamura refers to the telephoto ratio and not the "compactness of an overall length." Pet. Reply 18–19 (citing Ex. 1007, 1). Even assuming, *arguendo*, that the term "conventional" as disclosed in Kawamura does not apply to the length of Kawamura's lens assembly and instead applies only to Kawamura's telephoto ratio, that still would not alter our finding that a POSITA would not have considered Kawamura to disclose a "lightweight" or "compact" lens assembly as of the earliest priority date of the '408 patent. We are not persuaded for the same reason discussed above, that in the absence of a comparison between two imaging systems of differing sizes in Golan, the record supports a finding that "lightweight" would have been understood to refer to a larger-scale imaging system capable of accommodating a lens assembly of the size disclosed in Kawamura.

For the foregoing reasons, we are not persuaded that Petitioner's rationale for combining Golan and Kawamura is supported by sufficient rational underpinning. As such, we conclude that Petitioner has not shown by a preponderance of the evidence that independent claim 5 is unpatentable over the combination of Golan and Kawamura.

4. Analysis of Dependent Claim 6

As Petitioner's arguments for dependent claim 6 rely on the same rationale for combining as presented with respect to independent claim 5, we conclude that Petitioner has not established by a preponderance of the evidence that dependent claim 6 is unpatentable under 35 U.S.C. § 103 over the combination of Golan and Kawamura.

E. Petitioner's and Patent Owner's Objections to Demonstratives

Petitioner objects to various slides in Patent Owner's demonstratives for the oral hearing. Paper 29. Patent Owner objects to various slides in Petitioner's demonstratives for the oral hearing. Paper 30. As we do not rely on the demonstratives to reach the conclusion rendered in this Decision, we do not address either party's objections. Both Petitioner's and Patent Owner's objections to the demonstratives are dismissed as moot.

IV. CONCLUSION

For the foregoing reasons, we conclude that Petitioner has not established by a preponderance of the evidence that claims 5 and 6 of the '408 patent are unpatentable. In summary:

Claim(s)	**35 U.S.C. §**	**References/Basis**	**Claims Shown Unpatentable**	**Claims Not Shown Unpatentable**
5, 6	103	Golan, Kawamura		5, 6
Overall Outcome				**5, 6**

V. ORDER

In consideration of the foregoing, it is hereby:

ORDERED that claims 5 and 6 of the '408 patent have not been shown to be unpatentable;

FURTHER ORDERED that Petitioner's objections to the demonstratives are dismissed as moot;

FURTHER ORDERED that Patent Owner's objections to the demonstratives are dismissed as moot; and

FURTHER ORDERED that, because this is a Final Written Decision, parties to the proceeding seeking judicial review of the decision must comply with the notice and service requirements of 37 C.F.R. § 90.2.

For PETITIONER:

David W. O'Brien
Andrew S. Ehmke
Hong Shi
HAYNES AND BOONE, LLP
david.obrien.ipr@haynesboone.com
andy.ehmke.ipr@haynesboone.com
hong.shi.ipr@haynesboone.com

For PATENT OWNER:

Neil A. Rubin
C. Jay Chung
RUSS AUGUST & KABAT
nrubin@raklaw.com
jchung@raklaw.com

Trials@uspto.gov
Tel: 571-272-7822

Paper 41
Entered: July 27, 2022

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

APPLE INC.,
Petitioner,

v.

COREPHOTONICS, LTD.,
Patent Owner.

IPR2020-00489
U.S. Patent 10,015,408 B2

Before GREGG I. ANDERSON, MONICA S. ULLAGADDI, and JOHN R. KENNY, *Administrative Patent Judges.*

ULLAGADDI, *Administrative Patent Judge*.

DECISION
Denying Petitioner's Request on Rehearing
of the Final Written Decision
37 C.F.R. § 42.71
Denying Petitioner's Request to Admit and Consider New Evidence
Denying Patent Owner's Request to Admit and Consider New Evidence
37 C.F.R. § 42.5

I. INTRODUCTION

Apple Inc. ("Petitioner") filed a Petition to institute *inter partes* review of claims 5 and 6 of U.S. Patent No. 10,015,408 B2 (Ex. 1001, "the '408 patent") on February 5, 2020. Paper 2 ("Petition" or "Pet."). Corephotonics, Ltd. ("Patent Owner") filed a Preliminary Response. Paper 7. We instituted an *inter partes* review of each of the challenged claims on the ground set forth in the Petition. Paper 8. Subsequent to institution, Patent Owner filed a Patent Owner Response (Paper 13, "PO Resp."), Petitioner filed a Petitioner Reply (Paper 18), and Patent Owner thereafter filed a Sur-Reply (Paper 20).

An oral hearing was held on May 26, 2021 and a transcript of the hearing has been entered into the record. Paper 31. On July 26, 2021, we entered a Final Written Decision (Paper 32, "Decision" or "FWD") determining that Petitioner did not demonstrate by a preponderance of the evidence that any of the challenged claims were unpatentable. Petitioner requests rehearing (Paper 33, "Req. Reh'g") of our Decision.

In its Rehearing Request, Petitioner urges us to reconsider our Decision, and then also urges us to admit and consider new documents that became available after we entered our Decision. Specifically, Petitioner urges us to admit a brief ("Korean Brief") prepared and submitted by Patent Owner in connection with a proceeding before the Patent Court of Korea ("Korean Court").[1] Patent Owner filed a brief opposing the admission of the Korean Brief. Paper 34 ("PO Brief"). Patent Owner also urges us to admit and consider new documents. Specifically, Patent Owner filed a brief urging us to admit a certified translation of another brief,

---

[1] Petitioner attaches a certified translation of the Korean Brief to its Rehearing Request.

filed by a third party, LG Innotek Co., Ltd. ("LG Brief") in a proceeding before the 3rd Division of the Korean Court. Paper 35 ("PO LG Brief"). Petitioner opposed admission of the LG Brief. Paper 36 ("Opp. LG Brief"). For the reasons set forth below, Petitioner's Rehearing Request is denied. We further do not admit either the Korean Brief or the LG Brief.

II. LEGAL STANDARDS

A party requesting rehearing bears the burden of showing that a decision should be modified. 37 C.F.R. § 42.71(d). The party must specifically identify all matters it believes the Board misapprehended or overlooked, and the place where each matter was addressed previously in a motion, an opposition, or a reply. *Id.* A request for rehearing, therefore, is not an opportunity merely to disagree with the Board's assessment of the arguments or weighing of the evidence, or to present new arguments or evidence. *See, e.g.*, *Presidio Components, Inc. v. AVX Corporation*, IPR2015-01332, Paper 21, 4 (PTAB Feb. 21, 2016) ("Patent Owner's arguments in this regard amount to a mere disagreement with our analysis or conclusion. But mere disagreement with our analysis or conclusion is not a sufficient basis for rehearing. It is not an abuse of discretion to provide analysis or conclusion with which Patent Owner disagrees.").

III. THE PARTIES' ARGUMENTS

In the Final Written Decision, we determined that Petitioner had not met its burden of showing, by a preponderance of the evidence, that claims 5 and 6 of the '408 patent are unpatentable over U.S. Patent Application Publication No. 2012/0026366 A1 (Ex. 1005, "Golan") and Japanese Patent Application Publication No. S58-62609 (Ex. 1007, "Kawamura"). FWD 2; *see* Pet. 13–20.

Petitioner now requests that we reconsider the conclusion rendered in our Decision and instead conclude that claims 5 and 6 are unpatentable over the combination of Golan and Kawamura. Req. Reh'g 3.

A. Arguments Regarding the Final Written Decision

In Section II.A of its Request for Rehearing, Petitioner argues that, in determining a person of ordinary skill in the art ("POSITA") would not have been motivated to combine Golan and Kawamura, we relied on Patent Owner's "unsupported representations that [a] '***rich literature***' of miniature telephoto lens designs existed in 2013" and arguments that a POSITA would have looked to this "rich literature" instead of looking to Kawamura. Req. Reh'g 5 (quoting FWD 36 ("A POSITA would not have been motivated to go beyond [the] rich literature of miniature lens designs and try scaling old lenses." (quoting Ex. 2003 ¶ 87))) (citing PO Resp. 39; Paper 31, 29:21–24; Sur-Reply 14). Petitioner contends that Patent Owner directly contradicted its representation about the "'rich literature' of miniature telephoto lens designs" in a proceeding before the Korean Court and that, accordingly, our determination that Petitioner's challenge lacked a sufficient motivation to combine Golan and Kawamura is unsupported. *Id.* (emphasis omitted) (citing Ex. 1036, 2, 7).[2] *Infra* §§ IV.A–B.

In Section II.B of the Rehearing Request, Petitioner argues that neither Golan nor Kawamura are limited to their examples and that the Board misconstrued the scope of these references by limiting the disclosed devices to the specific dimensions set forth in the disclosed examples. *Id.* at 7–9 ("The Decision

---

[2] When referring to the Korean Brief, Petitioner cites to Exhibit 1036. A certified translation of the Korean Brief was filed as an attachment to Petitioner's Request for Rehearing, not as an exhibit.

effectively treated Golan's teachings as excluding scope that does not require a miniature telephoto lens, based solely on an exemplary image sensor in Golan's background. This is clear error."). Petitioner contends that our Decision "explained that 'disclosure of the 5 megapixel image sensor array in Golan supports the finding that Golan is at least applicable to miniature digital cameras and image sensors such as those used in mobile devices', but provided no explanation of why and how such 'at least applicable' finding operated as a limitation on a POSITA's understanding of Golan's scope, by excluding scope beyond the 'at least applicable' finding." Req. Reh'g 8 (citing FWD 34) (emphasis omitted). *Infra* §§ IV.C, IV.G.

Petitioner additionally argues that the Board improperly required that the supporting reference, U.S. Patent No. 8,896,697 B2 to Golan et al. (Ex. 1022, "Golan '697") "mention Golan or the invention described" to inform a POSITA's understanding of Golan. *See id.* at 11. Petitioner further argues that the Board made unsupported factual findings by not finding there was sufficient support for image sensors of Golan '697 to correspond to the device and method of Golan. *Id.* at 12 ("The Board's statement that '[t]here is no … evidence that Golan's teachings are applicable to larger-scale imaging systems' (FWD, at 34) is thus erroneous, because it ignores the disclosure in Golan '697 (incorporating provisional application No. 61/167,226, 'the '226 Provisional') of precisely such applications of the teachings of Golan to a larger-scale imaging system."). Petitioner further argues that our Decision "overlooked that Golan (APPL-1005) and Golan 697 (APPL-1022) are related patents, both claiming priority to the same provisional . . . and incorporating that same provisional by reference" and "[a] POSITA would have understood—from the face, common priority and incorporated content—correspondence between a related patent and patent publication from the same

provisional." *Id.* at 12 (citing Ex. 1005, code (60), ¶ 1; Ex. 1022, code (60), 1:7–10); *infra* § IV.D.

In Section II.C, Petitioner argues that our reliance on Dr. Moore's testimony was conclusory and ignored modifications well known to a POSITA. Req. Reh'g 16. Petitioner further contends that we erred in concluding that Petitioner's contention of predictable results was generic without analyzing Petitioner's arguments. *Id.* ("The Board ignored well-known modifications other than scaling, and ignored Dr. Sasián's detailed testimony (including lens design software analysis) regarding how a POSITA would have modified Kawamura, *not simply/only scaled* it, to smaller sizes") (citing Pet. Reply, 22–23; Ex. 1013 ¶¶ 28–33, Appendix B-ZEMAX analysis, ¶¶ 40–49); *infra* §§ IV.I–J.

Finally, Petitioner argues the Board erred by requiring bodily incorporation of Kawamura's exemplary reference into Golan's system and ignored modifications that were within a POSITA's skill. Req. Reh'g 16. Petitioner also argues that "the Decision incorrectly required conclusory proof of 'a finite number of identified, predictable solutions,' which is not necessary to show obviousness." *Id.* at 17 (citing FWD, 38 ("a POSITA would have understood that there were only a few options for telephoto lens design")). *Infra* §§ IV.H–K.

B. Arguments Regarding the Korean Brief

Petitioner argues that "good cause exists because PO's admission to the Korean tribunal directly contradicts the representations PO made to this one, and this tribunal was thereby misled into finding in PO's favor based on those misrepresentations." Req. Reh'g 1. According to Petitioner, "PO and its expert failed to identify any miniature telephoto lens design out of its alleged 'rich literature,' so the Board relied solely on PO's misrepresentation" but that "days after the FWD, Corephotonics admitted to the Korean tribunal that 'there were

hardly any telephoto lens assemblies applied to portable terminals' in 2013." *Id.* at 1–2 (citing Ex. 1036, 2, 7); *see id.* at 2 (citing *Ultratec, Inc. v. CaptionCall, LLC*, 872 F.3d 1267, 1271–75 (Fed. Cir. 2017) (abuse of discretion where Board refused to admit and consider conflicting evidence); *Paice LLC v. Toyota Motor Corp.*, 504 F.3d 1293, 1312 (Fed. Cir. 2007) (counsel statements weighed as evidentiary admissions)).

Petitioner further argues that "good cause exists because this new evidence could not have been presented earlier, as PO waited until after the FWD before making its contrary admission in Korea" and that "[t]he Board has found 'good cause' in similar circumstances." *Id.* at 2 (citing *Unified Patents v. MV3 Partners*, IPR2019-00474, Paper 16 at 1–4 (PTAB Aug. 5, 2019) (admitting transcript as new evidence on rehearing where hearing occurred after the Board's decision); *Ultratec*, 872 F.3d at 1272 ("inconsistent testimony did not exist sooner")).

Patent Owner responds that the statements in the Korean Brief cited by Petitioner do not show any contradiction on the part of Patent Owner. PO Brief 1 (explaining that the statements regarding lenses in before the Korean Tribunal dealt with lenses with a Total Track Length (TTL length of < 6.5 mm while scaling Kawamura to be compatible with Golan would lead to a lens with a TTL length of 13.49 mm). According to Patent Owner, "[e]ven assuming that ***no*** telephoto lenses for 'portable terminals' requiring TTL < 6.5 mm had existed in 2013, that would not contradict anything said by Corephotonics or relied on by the Board in the FWD concerning the availability of telephoto lens designs that could have been used instead of a scaled Kawamura lens." *Id.*

Patent Owner further argues that the statements in the Korean Brief were made only as statements about the undeveloped record in the Korean case, and

reflect the substantive difference between American and Korean patent law, namely, the requirement of an inventive step in Korean patent law. *Id*.

Patent Owner also argues that Petitioner's factual position based on the Korean Brief is contrary to what Petitioner itself has previously represented to the Board in other IPR proceedings. *Id.* at 1–2. According to Patent Owner, it is too late after the issuance of the Final Written Decision for Petitioner to change to a long-held factual position. *Id.* at 2.

We discuss the parties' arguments regarding the Korean Brief below in Section IV.A.

C. Arguments Regarding the LG Brief

Patent Owner argues that "[g]ood cause exists to admit the []certified translation of LG Innotek Co., Ltd.'s (LG) August 12 brief to the Patent Court of Korea" because "LG supplies a majority of the camera modules used by Apple, . . . account[ing] for a majority of LG Innotek's revenue" and the LG Brief "clearly shows that Apple's camera module supplier disagrees with the factual premise that Apple now asks the Board to accept: 'that there were almost no telephoto lens assemblies for small form factors available in 2013.'" PO LG Brief 1.

Patent Owner further argues that "the brief shows that Corephotonics' statement about 'one precedent document' in its brief was based on an incompletely developed factual record" and that LG "cites four new prior art references that purportedly show telephoto lens assemblies in a mobile phone." *Id.*

Finally, Patent Owner argues that

> the brief illustrates a difference in substantive law between Korea and the U.S. which underlies the Corephotonics statements Apple points to. Although LG's counsel is aware of the U.S. IPR proceedings, e.g. Attachment at 17, neither they nor Corephotonics mentioned in the Korean case the other mobile phone telephoto lens

> art Apple has cited in its IPRs. *See* Ex. 2015 at 112:7–114:18. That is because those other references were unpublished patent applications as of Corephotonics' priority date. While unpublished applications are considered to be known to the POSITA for purposes of obviousness in the United States, they are not considered within the prior art for the purposes of "inventive step" in Korea. KIPO Patent Examination Guidelines, January 2021 at 303–04, 341–43 (https://www.kipo.go.kr/upload/en/download/Patent_Examination_Guidelines_2021.pdf).

Id.

Petitioner responds that the LG Brief is a "*non-party* statement" that "is not relevant to the question presented by PO's Korean Brief: namely, whether, in fairness and the interests-of-justice, *PO* should be allowed to take directly contrary positions before different judicial tribunals in order to secure patentability of patents from the same field and timeframe." Opp. LG Brief 1.

We discuss the parties' arguments regarding the LG Brief below in Section IV.L.

IV. ANALYSIS

Turning to Petitioner's arguments, we begin by noting that Petitioner has not pointed us to precedent for admitting evidence after trial has concluded and after a Final Written Decision has issued. *See* Req. Reh'g 4–7. In *Huawei Device Co. v. Optis Cellular Tech.*, IPR2018-00816, Paper 19 at 4 (PTAB Jan. 8, 2019) (precedential), the Board determined that the standard for admitting new evidence with a rehearing request requires a showing of good cause. Separately, 37 C.F.R. § 42.123 requires that any supplemental evidence must be filed within *one month* of the date the trial is instituted and late submissions of evidence beyond this date must be in the interest of justice. *Id.* In the present proceeding, for the reasons discussed below, we did not solely rely on Dr. Moore's testimony regarding the

"rich literature of miniature telephoto lenses" and even if we disregard that testimony completely, the outcome of our Decision would not change as we explain in detail in Section IV.A below.

A. The Korean Brief Is Not Admitted

As to Petitioner's first argument in Section II.A, Petitioner is correct in noting that we credited Dr. Moore's testimony that "[a] POSITA would not have been motivated to go beyond [the] rich literature of miniature lens designs and try scaling old lenses, designed for different purposes, with little reason to expect the result would be manufacturable." Req. Reh'g 5; FWD 36 (quoting Ex. 2003 ¶ 87). This portion of Dr. Moore's testimony is not directly contradicted by the Korean Brief because, in the Korean Brief, Patent Owner states that "there were hardly any telephoto lens assemblies *applied to portable terminals* at the time the application of the invention of the subject patent was filed" noting that "only one . . . Reference 1 (Exhibit No. Eul-4) discloses the small telephoto lens assembly *for portable terminals* before the priority date of the invention of the subject patent." *Id*. (Korean Brief Attachment 2) (emphasis added); *see also id.* at 7 ("Since the technical concept of the telephoto lens assembly for a portable terminal was different from the general telephoto camera in many ways, <u>at the time of filing for the invention for the subject patent</u>, a person of ordinary skill in the art did not think that the telephoto lens assembly could be installed in the portable terminal). That is, Dr. Moore refers to a breadth of miniature lens designs, whereas the Korean Brief more particularly refers to a dearth of telephoto lens assemblies *applied* to portable terminals—the record does not indicate that the portable terminals mentioned in the Korean Brief are necessarily miniature. Thus, the admission of the Korean Brief is moot because its admission would not affect our analysis. Therefore, good cause does not exist, nor would it be in the interest of

justice, to admit the Korean Brief as it would expend judicial resources and expand the scope of a concluded trial without sufficient cause.

B. Petitioner's Challenge Was Deficient Even Absent Dr. Moore's Allegedly Contradictory Testimony

Even if we were to exclude this portion of testimony (i.e., had this portion of Dr. Moore's testimony been stricken from the record), our conclusion of obviousness would not change. Patent Owner's allegedly contradictory statements do not change the outcome in this case because Petitioner, not Patent Owner, bears the burden of showing that the claims were obvious under their proposed combination. *Dynamic Drinkware, LLC v. Nat'l Graphics, Inc.*, 800 F.3d 1375, 1378 (Fed. Cir. 2015). To prevail, Petitioner must prove unpatentability by a preponderance of the evidence. *See* 35 U.S.C. § 316(e) (2018); 37 C.F.R. § 42.1(d) (2019). For the reasons below in our discussion of Petitioner's arguments set forth in Sections II.B and II.C of its Rehearing Request, Petitioner did not meet this burden—Petitioner's challenge was deficient on its own, irrespective of whether we gave weight to this portion of Dr. Moore's testimony. Stated differently, even if we discredited Dr. Moore's testimony with regard to the "rich literature of miniature lens designs," for example, because of the statements in the Korean Brief, Petitioner failed to present sufficient evidence that supports a determination that a POSITA would have contemplated the proposed modifications, and ultimately, recognized the obviousness of the proposed combination of Golan and Kawamura.

C. Golan Is Not Limited to the Dimensions of Its Examples

Petitioner's arguments in Section II.B. of the Rehearing Request mischaracterize our Decision as limiting Golan and Kawamura to their examples. *See* Req. Reh'g 7–9. In our Decision, we noted that Golan expressly discloses a 5

megapixel image sensor array, but that "there is insufficient evidence of record to support the proposition that Golan's teachings are applicable to imaging systems that are of a scale larger than that of the miniature cameras and image sensors used in mobile devices." FWD 26. We based this determination, in relevant part, on Dr. Sasián's Reply Declaration (*see, e.g.*, Ex. 1013 ¶¶ 15–21, 28), in which he testified that Golan's teachings are applicable to imaging systems that are of a scale larger than that of the miniature cameras and image sensors used in the systems of Exhibits 1022, 1024, 1026, 1029–1032, 1034, and 1035, which were cited to support this testimony. We found this testimony to be unpersuasive because Exhibits 1022, 1024, 1026, 1029–1032, 1034, and 1035 do not address devices like those taught by Golan. Exhibits 1022, 1024, 1026, 1029–1032, 1034, and 1035 exemplify different sizes of imaging systems, but do not indicate that an image sensor array and device *of the type disclosed in Golan* —a dual lens, fixed focal length digital imaging system with two different fields of view—would have been understood to have the different (larger) dimensions and pixel resolutions of the magnitude of Kawamura.[3] *See* Ex. 1013 ¶ 18; PO Resp. 6–8 (citing-in-part Ex. 2015, 99:14–22); FWD 30 (citing Ex. 1013 ¶ 24 (citing Ex. 1005 ¶ 9)). The devices disclosed in Exhibits 1022, 1024, 1026, 1029–1032, 1034, and 1035 are smaller than that which is sufficient to accommodate a lens assembly of the size disclosed in Kawamura. And Dr. Sasián did not persuasively explain why the

[3] Exhibit 1029 discloses Kodak's EasyShare V610 dual-lens digital camera manual as having a 1/2.5" sensor and a 5.3-megapixel image. *Infra* § IV.E. Dr. Sasián does not indicate that the two lenses have a fixed focal length or different fields of view, nor does he persuasively explain why the teachings of Exhibit 1029 would applicable to a system with two lenses having fixed focal lengths and/or different fields of view. Ex. 1013 ¶ 21.

teachings of Exhibits 1022, 1024, 1026, 1029–1032, 1034, and 1035 would be applicable to Golan. Ex. 1013 ¶¶ 15–21, 28. We did not require, as claimed by Petitioner, that a supporting or background reference *must* mention Golan or its invention. *See* FWD 30–33; *see also* Req. Reh'g 11 (quoting FWD 30–33 ("[t]he Board then compounded its exclusion error, reasoning that a supporting reference must 'mention Golan or the invention described therein,' to inform a POSITA's understanding")). Instead, we determined that "Petitioner does not point to any portion of these exhibits that mentions Golan or the invention described therein," "[n]or does Petitioner point to evidence that sufficiently addresses the applicability of Golan's specific teachings to any particular product or imaging system described in the cited exhibits," nor does Dr. Sasián's Reply Declaration "offer perspective or sufficient explanation as to how a POSITA would have understood these exhibits to support his testimony and conclusions," nor does Petitioner "show sufficiently that the imaging systems in *any* of these exhibits achieve 'light weight electronic zoom' using 'two fixed focal length lenses and "two (or more) image sensors, having different fixed FOVs"' 'with a large lossless zooming range,' as Dr. Sasián testifies that Golan teaches." FWD 30 (citing Ex. 1013 ¶ 24 (citing Ex. 1005 ¶ 9)).

With regard to the cases we cited in our Decision as a "useful comparison" (i.e., using "*Cf.*"), *Abbott Labs. v. Dey, L.P.*, 287 F.3d 1097, 1104 (Fed. Cir. 2002) and *Astrazeneca AB v. Mut. Pharm. Co.*, 384 F.3d 1333, 1340 (Fed. Cir. 2004), Petitioner contends that neither case limits "the use of supplemental prior art references for showing a POSITA's 'background knowledge' and understanding of ***reference disclosure***" and that "[n]either case alters the rule that a ***prior art reference*** must be evaluated 'not only for what it expressly teaches, but also for what it fairly suggests.'" Req. Reh'g 11 (citing *Bradium Technologies LLC v.*

Iancu, 923 F. 3d 1032, 1049 (Fed. Cir. 2019)). We agree with Petitioner that a prior art reference must be evaluated in context and for what it fairly suggests. Petitioner, however, has not shown that the prior art it cites suggest the claimed invention.

D. Golan ’697 Is Not Dispositive as to how To Interpret Golan

As set forth above, it is Petitioner’s burden in an IPR proceeding to show that the contested claims are unpatentable. Here, Petitioner did not provide sufficient explanation, nor point to relevant case law, to explain why would should consider the disclosure of Golan ’697 to be part of Golan’s disclosure. Golan does not incorporate Golan ’697 by reference, and Petitioner did not point to any case law supporting a presumption that Golan and Golan ’697 refer to the same invention because both claim priority to and incorporate by reference the ’226 Provisional. *See* Req. Reh’g 12–15. We further note that Golan and Golan ’697 have different titles, abstracts, and specifications. *Compare* Ex. 1001 *with*, Ex. 1022. Petitioner also does not persuasively explain why Golan ’697 provides relevant background information for Golan.

Petitioner’s citations to *Unwired Planet, LLC v. Apple Inc.*, 829 F.3d 1353, 1359 (Fed. Cir. 2016) and *Home Diagnostics, Inc. v. LifeScan, Inc.*, 381 F.3d 1352, 1357 (Fed. Cir. 2004) are inapposite. *Unwired Planet* concerns how we interpret patent claims in light of the specification, and warns against limiting claims beyond their plain meaning to include a limitation disclosed in all of the embodiments or the only embodiment. *Unwired Planet*, 829 F.3d at 1359. Similarly, in *Home Diagnostics*, the Federal Circuit held that “the patent’s preferred embodiment is just that—one way of using the invention” and “[t]hat disclosure alone does not clearly and unambiguously disavow other ways of computing the endpoint *within the scope of the claim language*.” *Home*

Diagnostics, 381 F.3d at 1357 (emphasis added). As we have repeatedly stated, we are not limiting Golan to a device having the expressly-disclosed resolution (i.e., 5 megapixels) and correspondingly-dimensioned image sensor array and imaging device. We clarify that we determine, instead, that a POSITA would not have understood Golan to teach or suggest image sensor arrays or imaging devices of a size compatible with that of the telephoto lens assemblies taught or suggested by Kawamura.

In any event, Golan ’697 conveys little, if anything, about size and instead, was cited in Dr. Sasián’s testimony as disclosing “an imaging system, operatively mounted on an air-born vehicle.” Ex. 1013 ¶ 17. It does not even discuss scaling an image sensor array, imaging device, or lens assembly—at best, it discloses that “[a]n image sensor is generally subject to motion and vibrations which might distort a detected image of a scene” in which “[t]he motion can be linear, where the image sensor undergoes a linear displacement or scaling, and the motion can be angular, where the image sensor rotates about one or more axes.” Ex. 1022, 1:23–27.

E. Golan’s Disclosure of a 155-megapixel Resolution Relates to a Prior Art Single Optical Zoom Lens, not Its Dual-Lens Electronic Zoom Device

Petitioner notes that our finding that Golan only discloses a size of 5 megapixels “is, in fact, contrary to Golan’s disclosure” because Golan describes an example of a 155-megapixel image sensor array that can obtain an optical zoom of x36. Req. Reh’g 13 (citing Pet. Reply 7–11; Ex. 1005, Fig. 1, ¶ 13; Ex. 1022, 1:14–18, 1:67–2:1, 5:55–57; ’226 Provisional (expressly incorporated in Ex. 1005 and 1022), 3:12–13, Fig. 5 (describing Fig. 5 as a “zoom control sub-system for an air-born camera system”)). Petitioner’s argument does not provide the necessary context of this disclosure in Golan.

Golan discloses that

> *the present invention describes a continuous electronic zoom* for an image acquisition system, having multiple imaging devices each with a different fixed field of view (FOV). Using two (or more) *image sensors, having different fixed FOV*, facilitates a light weight electronic zoom with a large lossless zooming range. For example, a first image sensor has a 60° angle of view and a second image sensor has a 60° angle of view. Therefore, Wide_FOV=Narrow_FOV*6. Hence, switching between the image sensors provide a lossless *electronic* zoom of 6^2=36.

Ex. 1005 ¶ 9 (emphasis added). Golan contrasts this example of its invention having lossless *electronic* zoom of x36, which is achieved two image sensors each having *fixed* fields of view, with "obtain[ing] similar zoom (x36) by *optical means*," noting that, "for an output resolution frame of 400x300, the needed sensor array is" a 155-megapixel image sensor array. *Id.* ¶¶ 10, 13 (emphasis added). Golan explains that "[e]lectronic zoom is accomplished by cropping an image down to a centered area of the image with the same aspect ratio as the original . . . without any adjustment of the camera's optics, and no optical resolution is gained in the process." *Id.* ¶ 3. Golan explains that "[e]lectronic zoom *does not need moving mechanical elements, as does optical zoom*." *Id.* ¶ 7 (emphasis added). As part of its background, Golan recognizes that "[t]ypically, a camera with a large dynamic zoom range requires heavy and expensive lenses, as well as complex design" and as such, "[t]here is a need for and it would be advantageous to have image sensors, having static, light weight electronic zoom and a large lossless zooming range." *Id.* ¶¶ 7, 8. Thus, Golan *contrasts* the size of image sensor array (i.e., 155 megapixels) and lenses needed to achieve an optical zoom that is on the same order of electronic zoom achievable by Golan's invention.

Accordingly, we are not persuaded to alter our Decision based on this argument and the cited portions of Golan. More particularly, we are not persuaded

that Golan teaches or suggests using its invention—an imaging device with image sensors with fixed fields of view "having static, light weight electronic zoom and a large lossless zooming range"—with the contrasted "heavy and expensive lenses" image sensor arrays providing resolutions on the order of 155 megapixels and other correspondingly-sized components. *Accord* PO Resp. 20 (citing Ex. 2007 (Galstain), 4; Ex. 2003 ¶ 53) ("It is only in the largest, most expensive sensors, having pixel counts in excess of 10 megapixels, that pixels are larger.").

Petitioner contends that "[t]he Board's finding that Golan is limited to 'a miniature digital camera' with 'correspondingly-sized image sensors (*e.g.*, 1/4-inch or 1/3-inch miniature digital sensors)' also overlooked undisputed evidence that the exemplary 5MP (***resolution***) sensor may be implemented as a sensor of different ***dimension***, such as a nonminiature 1/2.5-inch sensor" and that "PO never addressed this evidence." Req. Reh'g 14 (citing Pet. Reply 11; Ex. 1029, 62; Ex. 1013 ¶ 21; FWD, 26, 28).

Our Decision states that "there is insufficient evidence of record to support the proposition that Golan's teachings are applicable to imaging systems that are of a scale larger than that of the miniature cameras and image sensors used in mobile devices" and describes "correspondingly-sized image sensors (e.g., 1/4" or 1/3" miniature digital sensors)" as exemplary, *not* limiting as Petitioner contends. FWD 26, 34. We note that Patent Owner's evidence, Table 1.1 comparing camera formats in Galstain, does not depict whether a 1/2.5" sensor would fall under the "miniature camera modules" heading or the "digital still cameras" heading. Ex. 2007, 62. The largest sensor under the "miniature camera modules" heading is 1/3" and the smallest sensor under the "digital still cameras" heading is 1/2.3"—if anything, a 1/2.5" sensor is closer to the size of sensor consistent with a digital still camera instead of the size of sensor consistent with a miniature camera module.

Accord Ex. 1029, 62 (Kodak's EasyShare V610 dual-lens digital camera manual disclosing a 1/2.5" sensor and a 5.3-megapixel image).

F. Petitioner's Challenge Does Not Explain "Relative to"

Irrespective of whether a 5-megapixel resolution as disclosed in Golan can be achieved using a 1/2.5" sensor, the only reason Petitioner provides for looking to Kawamura is that Golan does not disclose a specific lens prescription for its telephoto lens and as such, "a POSITA would have been motivated to apply Kawamura's teachings of tele lens because of the imaging benefits *and compactness of an overall length* with excellent image-formation performance as taught by Kawamura." Pet. 20 (citing Ex. 1003 ¶ 60) (emphasis added). But the Petition does not explain what the "compactness of an overall length" of Kawamura's telephoto lens assembly *is relative to*. The record does not sufficiently show how Kawamura's telephoto lens assembly would be considered compact enough in overall length to be used with, for example, a 1/2.5" sensor, nor does it explain how an approximately 7.9-inch telephoto lens assembly (i.e., with an approximately 200 mm focal length) would have been considered "lightweight" relative to Golan's invention, nor does it explain how the 7.9-inch lens assembly in 1983 would have been considered "lightweight" by a POSITA at the time of the invention of the '408 patent at least thirty years later.

To the extent that "Petitioner . . . take[s] the position that Kawamura's lens assembly is lightweight compared to some other lens assemblies—like the nearly ten pound Fujinon A36X14.5 lens," (*see* FWD 35), this position was not presented with sufficient particularity in the *Petition* at least because the Petition does not cite any teaching or suggestion of the weight or size of the single optically-variable zoom lens set forth in Golan's background. Although Dr. Sasián testifies that what constitutes "heavy" or "lightweight" is relative (Ex. 1013 ¶ 25), the Petition never

addresses what these terms are relative to. As such, we are not persuaded that we "misapprehended 'lightweight,' divorced from Golan's context of achieving 'lightweight' by using fixed focal length lenses in digital zoom rather than a single optically-variable zoom lens, and errantly required 'lightweight' to be lighter than some unspecified value presumptively associated with Golan's exemplary 5MP sensor." Req. Reh'g 14 (citing FWD 35).

G. Kawamura Is Not Limited to Its Examples

Petitioner contends that "Kawamura's 'Scope of Patent Claim' is not limited by focal length/dimension/weight, so the scope of Kawamura disclosure, including at least its scope of patent claim, also would not have been understood to be so limited." Req. Reh'g 10 (citing Pet. 15–17, 22–23; Ex. 1007, 1, Fig. 1; Ex. 1013 ¶¶ 29–33, Table 1). Petitioner contends that, instead, "Kawamura both teaches and fairly suggests a continuum of telephoto lens designs as a function of a desired focal length (F) using conditions (1) to (8) (FIG. 2A), which are ***not*** limited to any particular focal length or size/weight inferred therefrom (*see* FIGS. 2B-2C)." *Id*. This argument does not appear in the cited portions of the record (Pet. 15–17, 22–23 (citing Ex. 1007, 1 (Title, Scope of Patent Claim), Fig. 1; Ex. 1003 ¶¶ 53–59; Ex. 1013 ¶¶ 29–33, Table 1) and Petitioner's Figures 2A–2C do not appear to be have been presented before the Rehearing Request. *See* 37 C.F.R. § 42.71(d) ("The party must specifically identify all matters it believes the Board misapprehended or overlooked, *and the place where each matter was addressed previously in a motion, an opposition, or a reply*." (emphasis added)). While we do *not* limit Kawamura to only the ~200mm focal length of its examples, the record does not support a finding that a POSITA would have understood Kawamura to teach or suggest a telephoto lens assembly with a lens prescription

that has any focal length, size, and weight, such that it would have been considered "lightweight" or compact in overall length relative to Golan's invention or other, background disclosures, or relative a POSITA's understanding of those terms at the time of the invention of the '408 patent.

H. The Decision Did Not Require Petitioner To Show a Finite Number of Options

Aside from asserting that Kawamura's telephoto lens assembly had a "compactness of overall length," Petitioner does not provide any standalone, non-generic reason for looking to Kawamura, i.e., other than the fact that Golan does not disclose a specific lens prescription for its telephoto lens. In our Decision, we noted that "there is insufficient evidence of record to support a finding that a POSITA would have understood that there were only a few options for telephoto lens designs from which to choose such that Kawamura's lens assembly would have been the "obvious" choice." FWD 38 (citing *Procter & Gamble Co. v. Teva Pharm. USA, Inc.*, 566 F.3d 989, 996 (Fed. Cir. 2009)). We did *not* make it a requirement for Petitioner to show a finite number of options for telephoto lenses or miniature telephoto lenses. In the absence of any persuasive reason to look to Kawamura in particular (we explained above why the reason about Kawamura's disclosure of "compactness of overall length" was not persuasive), we *further* noted that did not Petitioner remedy the deficiency by persuasively explaining that there were few or no miniature telephoto lens designs to look to (Petitioner did not make this argument until its Reply) such that combining Kawamura with Golan would have been obvious to POSITA—we did not *require* Petitioner to show this. FWD 38 (citing *Procter & Gamble Co. v. Teva Pharm. USA, Inc.*, 566 F.3d 989, 996 (Fed. Cir. 2009) ("We *further* note that there is insufficient evidence of record to support a finding that a POSITA would have understood that there were only a few options for telephoto lens designs from which to choose such that Kawamura's

lens assembly would have been the 'obvious' choice." (emphasis added)); *see also* Ex. 2015, 114:14–18 (Dr. Sasián's testimony acknowledging there were several, well-known "lens designs that were publicly known for telephoto and miniature cameras" during the relevant timeframe).

Supporting Petitioner's rationale for combining Golan and Kawamura, Dr. Sasián testified that any needed modification would have been within the level of ordinary skill in the art and specifically, that lens scaling was a well-known practice in lens design. Ex. 1003 ¶¶ 63, 64 (quoting Ex. 1006 ("A lens prescription can be scaled to any desired focal length simply by multiplying all of its dimensions by the same constants. All of the linear aberration measures will then be scaled by the same factor.")). Dr. Sasián's testimony is that Kawamura *could* be scaled, but doesn't explain why a POSITA would think Kawamura was small enough or should be scaled to be small enough to be compatible with Golan's invention. *See id.* ¶ 64. *See Belden Inc. v. Berk-Tek LLC*, 805 F.3d 1064, 1073 (Fed. Cir. 2015) ("[O]bviousness concerns whether a skilled artisan not only could have made but would have been motivated to make the combinations or modifications[.]").

I. The Decision Did Not Ignore or Misunderstand Dr. Sasián's Testimony

Petitioner's arguments in Section II.C of the Rehearing Request rehash arguments considered fully and rejected in our Final Written Decision, and fail to show that we misapprehended or misconstrued those arguments in reaching that conclusion. *See* Req. Reh'g 16 (citing Pet. Reply 22–23; Ex. 1013 ¶¶ 28–33, Appendix B-ZEMAX analysis, ¶¶ 40–49) ("The Board ignored well-known modifications other than scaling, and ignored Dr. Sasián's detailed testimony (including lens design software analysis) regarding how a POSITA would have modified Kawamura, *not simply/only scaled* it, to smaller sizes."). In using the

term "scaling" in the Final Written Decision and in this Decision, we use it in the same manner as Petitioner and Dr. Sasián, that is, to encompass scaling and additional, attendant modifications:

> A POSITA would have *scaled* the Kawamura lens prescriptions to fit into a digital camera of Golan while maintaining the compactness and an excellent image-formation performance. As shown with examples in Table 1 below, a POSITA would have understood that *sensors of various formats may be used in the combination of Golan and Kawamura based on the application*, *would have applied the appropriate scaling factor based on the image sensor format* (e.g., scaling factors less than 10 for image sensors of 1/3" or greater), *and would have found that modifications of Kawamura's lens for the combination is practical*. Further, a POSTA would have found it practical, and indeed, would have *modified the field of view of Kawamura's lens for a tele field of view* that's appropriate for a particular application (e.g., conventional digital still cameras, air-born vehicles/drones applications, etc.), including the example Narrow_FOV described in Golan.

Ex. 1013 ¶ 30 (emphasis added). If it was not persuasive to us that a POSITA would scale Kawamura, it is not clear why we would have considered and found Dr. Sasián's testimony that a POSITA "would have found it practical, and indeed, would have modified the field of view of Kawamura's lens for a tele field of view that's appropriate for a particular application (e.g., conventional digital still cameras, air-born vehicles/drones applications, etc.), including the example Narrow_FOV described in Golan" sufficiently persuasive on its own. *Id*.

In the Rehearing Request, Petitioner argues that the Board misunderstood Dr. Sasián's past statements. Petitioner argues that Dr. Sasián claimed lenses cannot be *simply* be scaled, which Petitioner alleges the Board construed as meaning lenses are *unable* to be scaled down. *See* Req. Reh'g 15–16. Petitioner misconstrues our Decision—we were not persuaded that Kawamura's lens

assembly would meet the needs identified in Golan, such as being lightweight. *See* FWD 35–36. Additionally, we noted that Dr. Sasián's testimony is contradicted by his position taken in a published article that a POSITA may be dissuaded from such scaling due to an increase in fabrication and cost of materials, which are relevant considerations for determining if there is sufficient motivation to combine. FWD 36–37 (citing Ex. 2008, 1). Therefore, it is relevant whether Petitioner's expert takes the position that Kawamura's lens *assembly* cannot *simply* be scaled and cheaply—the above considerations and the difficulty of scaling weigh against motivation to combine. *See id*. As discussed in the next section, we also considered Patent Owner's arguments and the portions of Dr. Moore's testimony that are supported by sufficient underlying evidence.

J. Patent Owner's Arguments and Dr. Moore's Testimony Are Not Conclusory and Are Supported by Evidence of Record

Contrary to Petitioner's assertion, the Board's analysis did not adopt the conclusory opinion of Dr. Moore without evidence. We looked to considerations such as: manufacturing and fabrication constraints, material properties, diffraction and geometrical aberrations, which we were persuaded would have dissuaded a POSITA from scaling Kawamura in one of Petitioner's alternative theories. *See* FWD 22, 23, 36–37 (citing-in-part Ex. 2008 (Reshidko), 1; Ex. 2012 (Bareau), 1). We clarify for the record we did not solely consider Reshidko and Bareau for the purposes of impeaching Dr. Sasián's testimony—we found Patent Owner's argument supported by the cited portions of these pieces of underlying evidence. Ex. 2008, 1; Ex. 2012, 1, 3; PO Resp. 35–37.

K. The Decision Did Not Misapply KSR nor Did the Decision Require Bodily Incorporation of Kawamura into Golan

For similar reasons, we likewise disagree with Petitioner's argument that we misapplied the law under *KSR International Co. v. Teleflex, Inc.*, 550 U.S. 398 (2007), and required bodily incorporation of Kawamura's telephoto lens assembly. *See* Req. Reh'g 17. We did not do so. Instead, we determined that Petitioner did not present sufficient evidence that a POSITA would have been motivated to combine Kawamura's lens assembly with Golan, particularly in light of the above considerations relating to scaling, as set forth above. FWD 35 ("Petitioner does not present sufficient evidence that a POSITA . . . would have thought of Kawamura's 7-inch lens assembly as "lightweight" or "compact[.]"). Because Petitioner did not provide sufficient underlying evidence to support their reason, and because there are significant countervailing considerations a POSITA would have balanced, Petitioner did not meet this burden, and was not able to sufficiently show a motivation to combine that is supported by sufficient rational underpinning.

L. The LG Brief Is Not Admissible

Good cause does not exist, nor is it in the interests of justice, to admit the LG brief because even if it were admitted, it would not alter the outcome of our Decision. That is, it would not make any fact relied upon in our Decision more or less likely. This is due to the fact that LG brief includes only statements by a non-party to the present proceeding to a tribunal different from the one that adjudicates this IPR proceeding.

V. CONCLUSION

For the foregoing reasons, we are not persuaded that we misapprehended or overlooked any matter.

VI. ORDER

In consideration of the foregoing, it is hereby:

ORDERED that Petitioner's Request for Rehearing is *denied*;

FURTHER ORDERED that Petitioner's request to admit and consider the Korean Brief is denied; and

FURTHER ORDERED that Patent Owner's request to admit and consider the LG brief is denied.

For PETITIONER:

David W. O'Brien
Andrew S. Ehmke
Hong Shi
HAYES AND BOONE, LLP
David.obrien.ipr@haynesboone.com
Andy.ehmke.ipr@haynesboone.com
Hong.shi.ipr@haynesboone.com

For PATENT OWNER:

Neil Rubin,
C. Jay Chung,
Marc A. Fenster,
James S. Tsuei,
RUSS AUGUST & KABAT
nrubin@raklaw.com
jchung@raklaw.com
mfenster@raklaw.com
jtsuei@raklaw.com

US010015408B2

(12) **United States Patent**
Shabtay et al.

(10) **Patent No.: US 10,015,408 B2**
(45) **Date of Patent: Jul. 3, 2018**

(54) **DUAL APERTURE ZOOM DIGITAL CAMERA**

(71) Applicant: **Corephotonics Ltd.**, Tel-Aviv (IL)

(72) Inventors: **Gal Shabtay**, Tel Aviv (IL); **Ephraim Goldenberg**, Ashdod (IL); **Oded Gigushinski**, Herzlia (IL); **Noy Cohen**, Tel-Aviv (IL)

(73) Assignee: **Corephotonics Ltd.**, Tel Aviv (IL)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **15/424,853**

(22) Filed: **Feb. 5, 2017**

(65) **Prior Publication Data**

US 2017/0150061 A1 May 25, 2017

Related U.S. Application Data

(63) Continuation of application No. 14/880,251, filed on Oct. 11, 2015, which is a continuation of application (Continued)

(51) **Int. Cl.**
H04N 5/232 (2006.01)
H04N 5/225 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H04N 5/23296*** (2013.01); ***G02B 13/0015*** (2013.01); ***G02B 27/0075*** (2013.01); ***H04N 5/2258*** (2013.01); ***H04N 5/23212*** (2013.01)

(58) **Field of Classification Search**
CPC H04N 5/23296; G02B 13/0015
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

9,405,099	B2 *	8/2016	Jo	G02B 13/0045
9,576,369	B2 *	2/2017	Venkataraman	H01L 27/14618

(Continued)

FOREIGN PATENT DOCUMENTS

JP	2013106289 A *	5/2013		H04N 5/2258
JP	5741395	7/2015		

OTHER PUBLICATIONS

JP 2013106289 A; May 2013; Machine English Translation; Japan Platform Patent Information; pp. 1-18.*

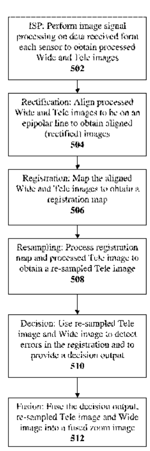
(Continued)

Primary Examiner — Cynthia Segura
(74) *Attorney, Agent, or Firm* — Nathan & Associates Patent Agents Ltd.; Menachem Nathan

(57) **ABSTRACT**

A dual-aperture zoom digital camera operable in both still and video modes. The camera includes Wide and Tele imaging sections with respective lens/sensor combinations and image signal processors and a camera controller operatively coupled to the Wide and Tele imaging sections. The Wide and Tele imaging sections provide respective image data. The controller is configured to combine in still mode at least some of the Wide and Tele image data to provide a fused output image from a particular point of view, and to provide without fusion continuous zoom video mode output images, each output image having a given output resolution, wherein the video mode output images are provided with a smooth transition when switching between a lower zoom factor (ZF) value and a higher ZF value or vice versa, and wherein at the lower ZF the output resolution is determined by the Wide sensor while at the higher ZF value the output resolution is determined by the Tele sensor.

7 Claims, 8 Drawing Sheets



Related U.S. Application Data

No. 14/365,711, filed as application No. PCT/IB2014/062180 on Jun. 12, 2014, now Pat. No. 9,185,291.

(60) Provisional application No. 61/834,486, filed on Jun. 13, 2013.

(51) **Int. Cl.**
G02B 13/00 (2006.01)
G02B 27/00 (2006.01)

(56) **References Cited**

U.S. PATENT DOCUMENTS

9,633,442 B2* 4/2017 Venkataraman G06T 7/593
2006/0187312 A1 8/2006 Labaziewicz et al.
2007/0229697 A1* 10/2007 Choi H04N 5/2257 348/345
2008/0030592 A1* 2/2008 Border H04N 5/232 348/218.1
2008/0187310 A1 8/2008 Tanaka
2008/0218613 A1 9/2008 Jenson et al.
2009/0002839 A1 1/2009 Sato
2010/0277269 A1 11/2010 Scarff
2011/0080487 A1 4/2011 Venkataraman et al.
2011/0129210 A1* 6/2011 McGucken F16M 13/02 396/422
2012/0074227 A1* 3/2012 Ferren G02B 13/0065 235/462.21
2012/0206458 A1* 8/2012 El Dokor G06F 3/0421 345/423
2012/0314296 A1* 12/2012 Shabtay G02B 13/18 359/662
2013/0182335 A1* 7/2013 Tsai G02B 13/0045 359/714
2013/0215289 A1* 8/2013 Vitsnudel H04N 5/232 348/231.99
2013/0335833 A1* 12/2013 Liao G02B 13/0045 359/713
2014/0009585 A1* 1/2014 Campbell H04N 13/0203 348/47
2015/0009395 A1* 1/2015 Ono H04N 5/2254 348/360
2015/0161798 A1* 6/2015 Venkataraman G01P 3/38 348/47
2015/0198784 A1* 7/2015 Bone G02B 13/004 359/708
2017/0102513 A1* 4/2017 Ogata G02B 7/021
2017/0249053 A1* 8/2017 El Dokor G06F 3/0421
2017/0276911 A1* 9/2017 Huang G02B 13/0045

OTHER PUBLICATIONS

European Supplementary Search report in related EP patent application 14810366.6, dated Apr. 6, 2016, 4 pages.

* cited by examiner

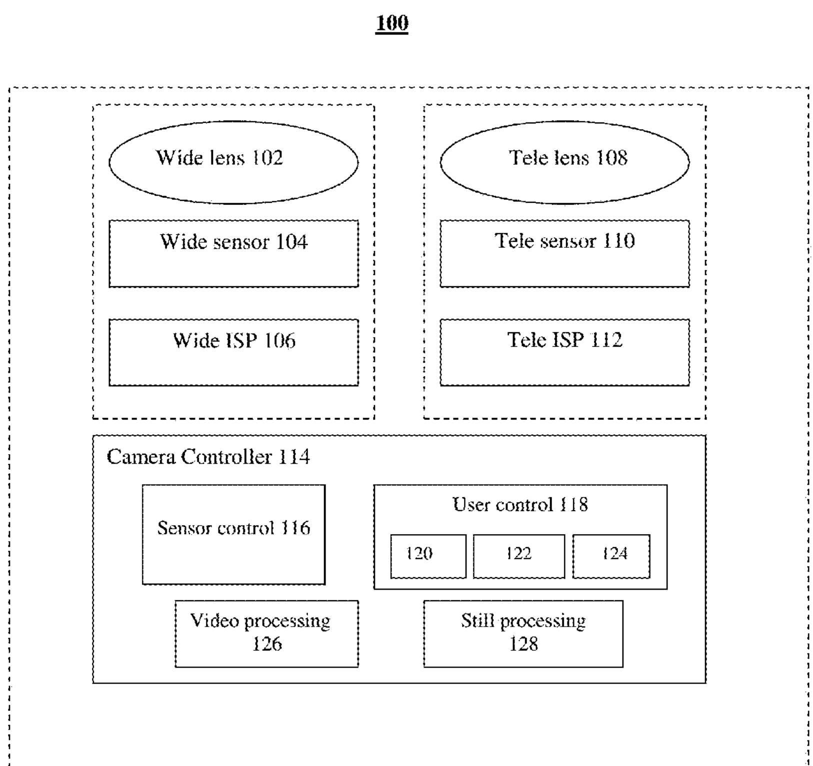

100
Wide lens 102
Wide sensor 104
Wide ISP 106
Tele lens 108
Tele sensor 110
Tele ISP 112
Camera Controller 114
Sensor control 116
User control 118
120
122
124
Video processing 126
Still processing 128

FIG. 1A

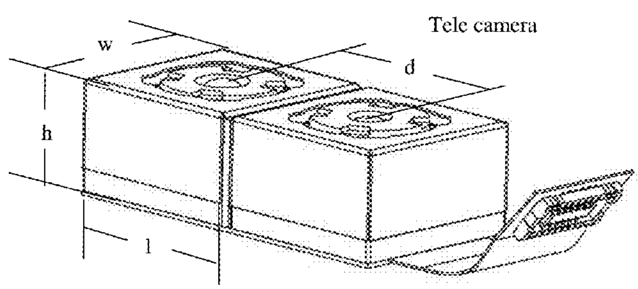
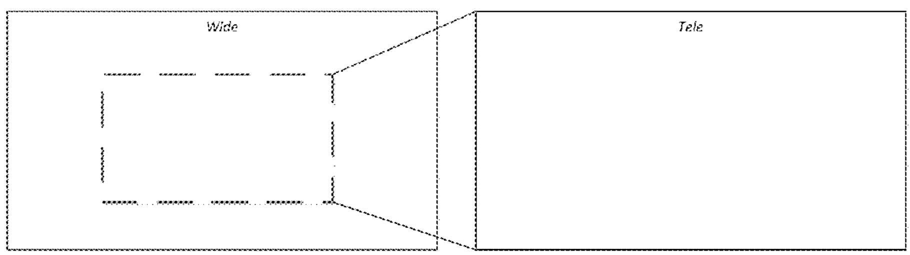
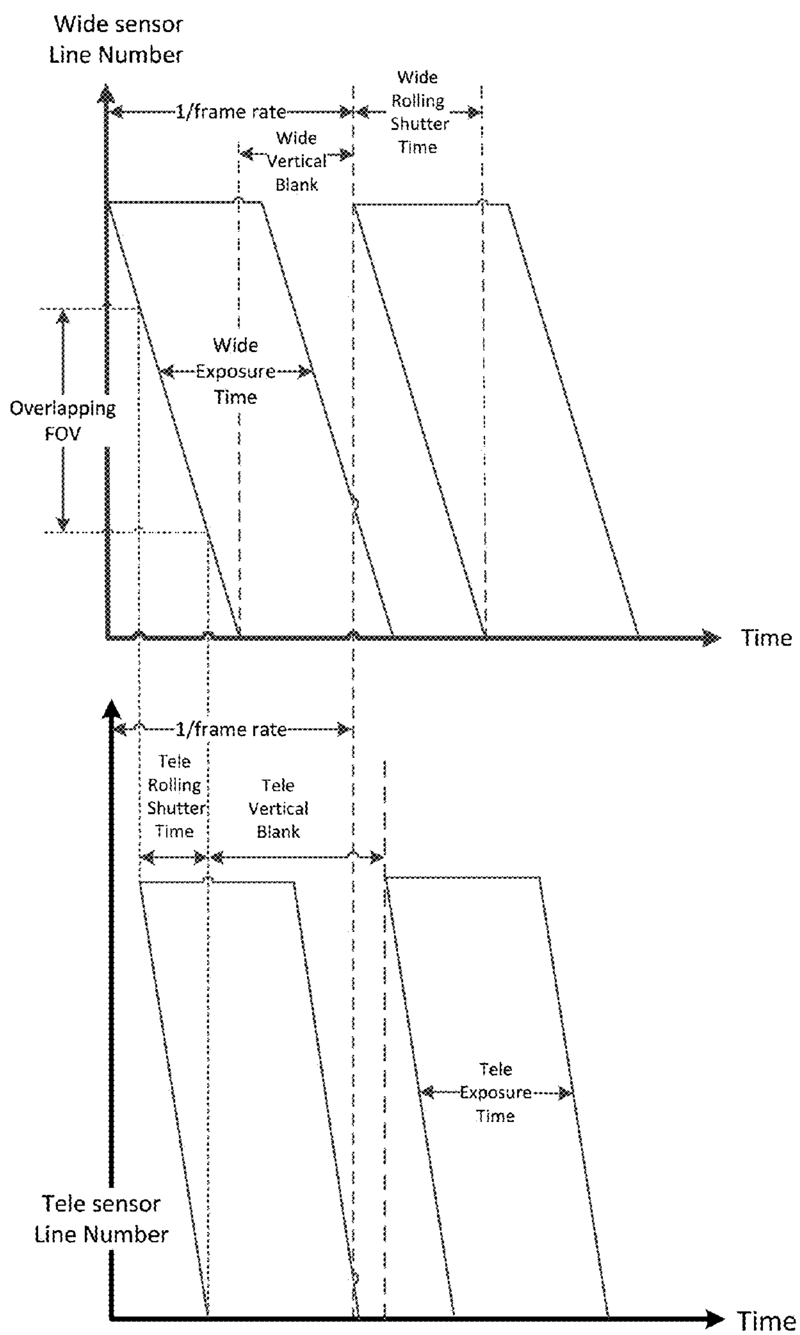

Tele camera
w
d
h
l

FIG. 1B



202 204

FIG. 2



Wide sensor Line Number
1/frame rate
Wide Vertical Blank
Wide Rolling Shutter Time
Wide Exposure Time
Overlapping FOV
Time
1/frame rate
Tele Rolling Shutter Time
Tele Vertical Blank
Tele Exposure Time
Tele sensor Line Number
Time

FIG. 3

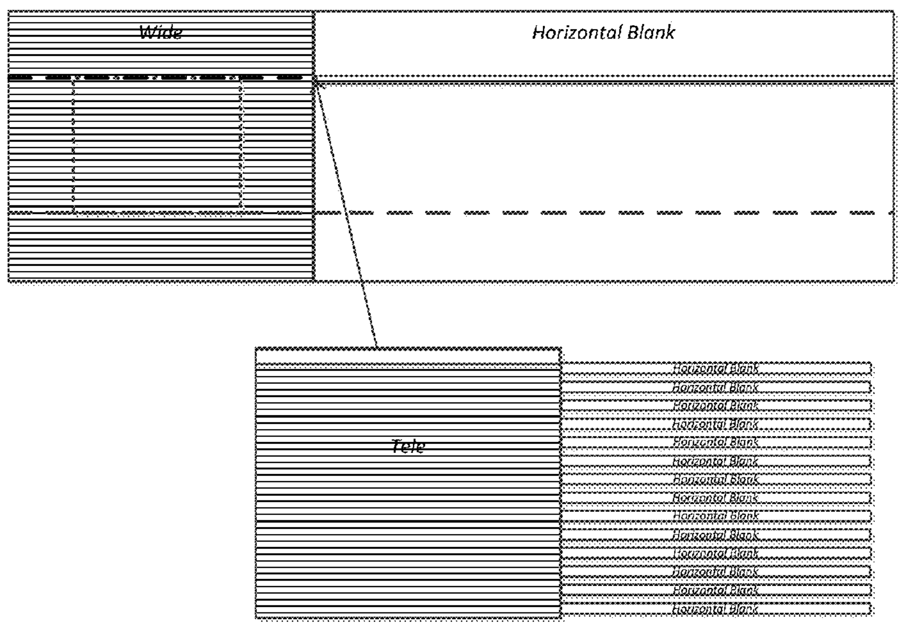

Wide
Horizontal Blank
Tele
Horizontal Blank
Horizontal Blank
Horizontal Blank
Horizontal Blank
Horizontal Blank
Horizontal Blank
Horizontal Blank
Horizontal Blank
Horizontal Blank
Horizontal Blank
Horizontal Blank
Horizontal Blank
Horizontal Blank
Horizontal Blank

FIG. 4

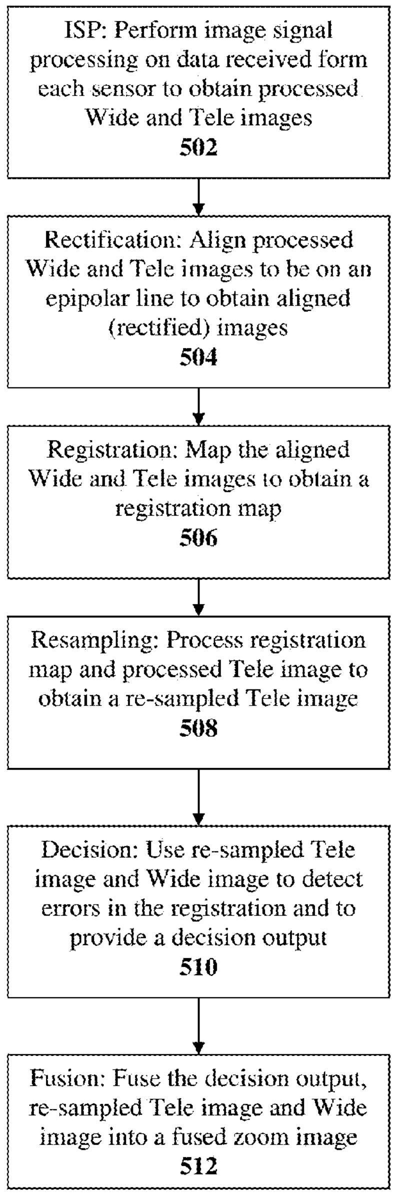

ISP: Perform image signal processing on data received form each sensor to obtain processed Wide and Tele images
502
Rectification: Align processed Wide and Tele images to be on an epipolar line to obtain aligned (rectified) images
504
Registration: Map the aligned Wide and Tele images to obtain a registration map
506
Resampling: Process registration map and processed Tele image to obtain a re-sampled Tele image
508
Decision: Use re-sampled Tele image and Wide image to detect errors in the registration and to provide a decision output
510
Fusion: Fuse the decision output, re-sampled Tele image and Wide image into a fused zoom image
512

FIG. 5

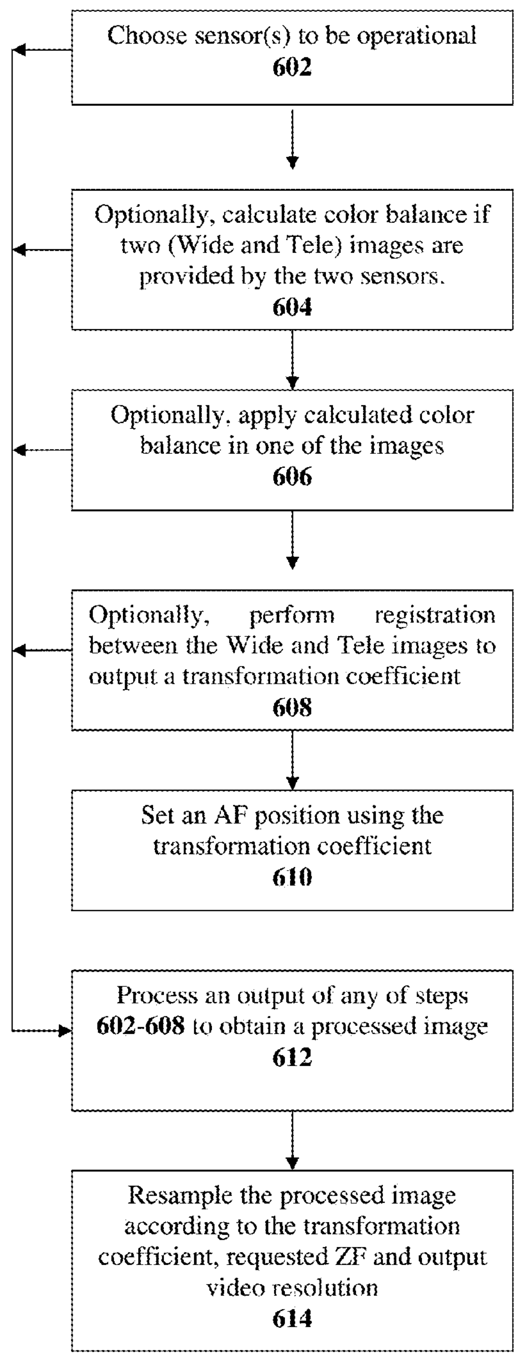

Choose sensor(s) to be operational
602
Optionally, calculate color balance if two (Wide and Tele) images are provided by the two sensors.
604
Optionally, apply calculated color balance in one of the images
606
Optionally, perform registration between the Wide and Tele images to output a transformation coefficient
608
Set an AF position using the transformation coefficient
610
Process an output of any of steps 602-608 to obtain a processed image
612
Resample the processed image according to the transformation coefficient, requested ZF and output video resolution
614

FIG. 6

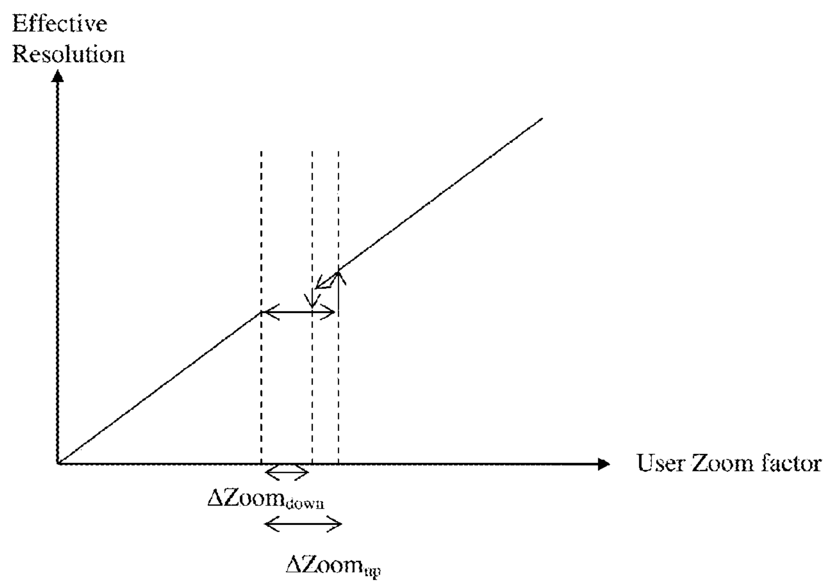

Effective
Resolution
User Zoom factor
$\Delta Zoom_{down}$
$\Delta Zoom_{up}$

FIG. 7

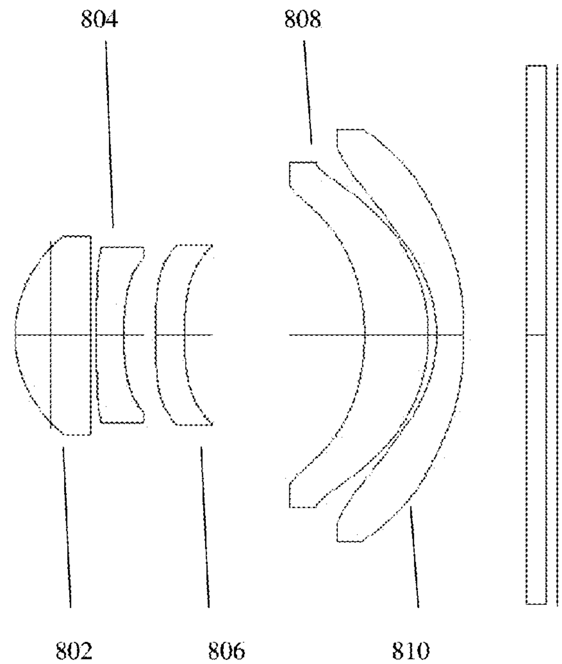


FIG. 8

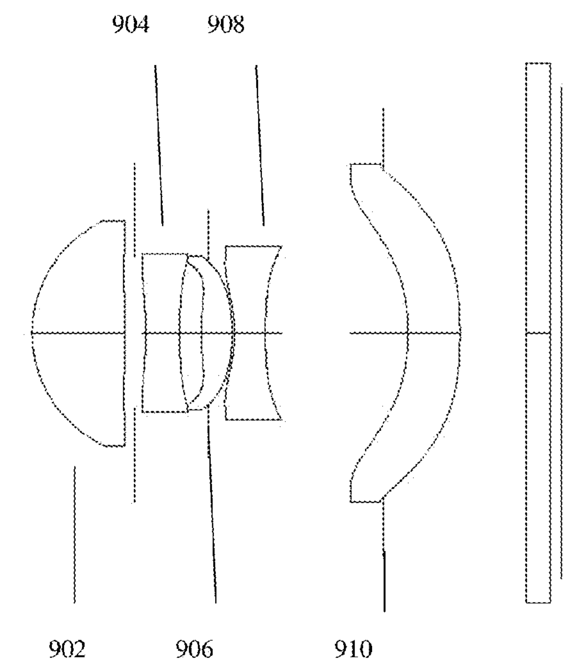


FIG. 9

DUAL APERTURE ZOOM DIGITAL CAMERA

CROSS REFERENCE TO RELATED APPLICATIONS

This application is a Continuation application of U.S. patent application Ser. No. 14/880,251 filed Oct. 11, 2015 (now allowed), which was a Continuation application of U.S. patent application Ser. No. 14/365,711 filed Jun. 16, 2014 (issued as U.S. Pat. No. 9,185,291), which was a 371 application from international patent application PCT/IB2014/062180 filed Jun. 12, 2014, and is related to and claims priority from U.S. Provisional Patent Application No. 61/834,486 having the same title and filed Jun. 13, 2013, which is incorporated herein by reference in its entirety.

FIELD

Embodiments disclosed herein relate in general to digital cameras and in particular to thin zoom digital cameras with both still image and video capabilities

BACKGROUND

Digital camera modules are currently being incorporated into a variety of host devices. Such host devices include cellular telephones, personal data assistants (PDAs), computers, and so forth. Consumer demand for digital camera modules in host devices continues to grow.

Host device manufacturers prefer digital camera modules to be small, so that they can be incorporated into the host device without increasing its overall size. Further, there is an increasing demand for such cameras to have higher-performance characteristics. One such characteristic possessed by many higher-performance cameras (e.g., standalone digital still cameras) is the ability to vary the focal length of the camera to increase and decrease the magnification of the image. This ability, typically accomplished with a zoom lens, is known as optical zooming. "Zoom" is commonly understood as a capability to provide different magnifications of the same scene and/or object by changing the focal length of an optical system, with a higher level of zoom associated with greater magnification and a lower level of zoom associated with lower magnification. Optical zooming is typically accomplished by mechanically moving lens elements relative to each other. Such zoom lenses are typically more expensive, larger and less reliable than fixed focal length lenses. An alternative approach for approximating the zoom effect is achieved with what is known as digital zooming. With digital zooming, instead of varying the focal length of the lens, a processor in the camera crops the image and interpolates between the pixels of the captured image to create a magnified but lower-resolution image.

Attempts to use multi-aperture imaging systems to approximate the effect of a zoom lens are known. A multi-aperture imaging system (implemented for example in a digital camera) includes a plurality of optical sub-systems (also referred to as "sub-cameras"). Each sub-camera includes one or more lenses and/or other optical elements which define an aperture such that received electro-magnetic radiation is imaged by the optical sub-system and a resulting image is directed towards a two-dimensional (2D) pixelated image sensor region. The image sensor (or simply "sensor") region is configured to receive the image and to generate a set of image data based on the image. The digital camera may be aligned to receive electromagnetic radiation associated with scenery having a given set of one or more objects. The set of image data may be represented as digital image data, as well known in the art. Hereinafter in this description, "image" "image data" and "digital image data" may be used interchangeably. Also, "object" and "scene" may be used interchangeably.

Multi-aperture imaging systems and associated methods are described for example in US Patent Publications No. 2008/0030592, 2010/0277619 and 2011/0064327. In US 2008/0030592, two sensors are operated simultaneously to capture an image imaged through an associated lens. A sensor and its associated lens form a lens/sensor combination. The two lenses have different focal lengths. Thus, even though each lens/sensor combination is aligned to look in the same direction, each captures an image of the same subject but with two different fields of view (FOVs). One sensor is commonly called "Wide" and the other "Tele". Each sensor provides a separate image, referred to respectively as "Wide" (or "W") and "Tele" (or "T") images. A W-image reflects a wider FOV and has lower resolution than the T-image. The images are then stitched (fused) together to form a composite ("fused") image. In the composite image, the central portion is formed by the relatively higher-resolution image taken by the lens/sensor combination with the longer focal length, and the peripheral portion is formed by a peripheral portion of the relatively lower-resolution image taken by the lens/sensor combination with the shorter focal length. The user selects a desired amount of zoom and the composite image is used to interpolate values from the chosen amount of zoom to provide a respective zoom image. The solution offered by US 2008/0030592 requires, in video mode, very large processing resources in addition to high frame rate requirements and high power consumption (since both cameras are fully operational).

US 2010/0277619 teaches a camera with two lens/sensor combinations, the two lenses having different focal lengths, so that the image from one of the combinations has a FOV approximately 2-3 times greater than the image from the other combination. As a user of the camera requests a given amount of zoom, the zoomed image is provided from the lens/sensor combination having a FOV that is next larger than the requested FOV. Thus, if the requested FOV is less than the smaller FOV combination, the zoomed image is created from the image captured by that combination, using cropping and interpolation if necessary. Similarly, if the requested FOV is greater than the smaller FOV combination, the zoomed image is created from the image captured by the other combination, using cropping and interpolation if necessary. The solution offered by US 2010/0277619 leads to parallax artifacts when moving to the Tele camera in video mode.

In both US 2008/0030592 and US 2010/0277619, different focal length systems cause Tele and Wide matching FOVs to be exposed at different times using CMOS sensors. This degrades the overall image quality. Different optical F numbers ("F#") cause image intensity differences. Working with such a dual sensor system requires double bandwidth support, i.e. additional wires from the sensors to the following HW component. Neither US 2008/0030592 nor US 2010/0277619 deal with registration errors. Neither US2008/000592 nor US 2010/0277619 refer to partial fusion, i.e. fusion of less than all the pixels of both Wide and Tele images in still mode.

US 2011/0064327 discloses multi-aperture imaging systems and methods for image data fusion that include providing first and second sets of image data corresponding to an imaged first and second scene respectively. The scenes

overlap at least partially in an overlap region, defining a first collection of overlap image data as part of the first set of image data, and a second collection of overlap image data as part of the second set of image data. The second collection of overlap image data is represented as a plurality of image data sub-cameras such that each of the sub-cameras is based on at least one characteristic of the second collection, and each sub-camera spans the overlap region. A fused set of image data is produced by an image processor, by modifying the first collection of overlap image data based on at least a selected one of, but less than all of, the image data sub-cameras. The systems and methods disclosed in this application deal solely with fused still images.

None of the known art references provide a thin (e.g. fitting in a cell-phone) dual-aperture zoom digital camera with fixed focal length lenses, the camera configured to operate in both still mode and video mode to provide still and video images, wherein the camera configuration uses partial or full fusion to provide a fused image in still mode and does not use any fusion to provide a continuous, smooth zoom in video mode.

Therefore there is a need for, and it would be advantageous to have thin digital cameras with optical zoom operating in both video and still mode that do not suffer from commonly encountered problems and disadvantages, some of which are listed above.

SUMMARY

Embodiments disclosed herein teach the use of dual-aperture (also referred to as dual-lens or two-sensor) optical zoom digital cameras. The cameras include two sub-cameras, a Wide sub-camera and a Tele sub-camera, each sub-camera including a fixed focal length lens, an image sensor and an image signal processor (ISP). The Tele sub-camera is the higher zoom sub-camera and the Wide sub-camera is the lower zoom sub-camera. In some embodiments, the lenses are thin lenses with short optical paths of less than about 9 mm. In some embodiments, the thickness/effective focal length (EFL) ratio of the Tele lens is smaller than about 1. The image sensor may include two separate 2D pixelated sensors or a single pixelated sensor divided into at least two areas. The digital camera can be operated in both still and video modes. In still mode, zoom is achieved "with fusion" (full or partial), by fusing W and T images, with the resulting fused image including always information from both W and T images. Partial fusion may be achieved by not using fusion in image areas where the Tele image is not focused. This advantageously reduces computational requirements (e.g. time).

In video mode, optical zoom is achieved "without fusion", by switching between the W and T images to shorten computational time requirements, thus enabling high video rate. To avoid discontinuities in video mode, the switching includes applying additional processing blocks, which include image scaling and shifting.

In order to reach optical zoom capabilities, a different magnification image of the same scene is captured (grabbed) by each camera sub-camera, resulting in FOV overlap between the two sub-cameras. Processing is applied on the two images to fuse and output one fused image in still mode. The fused image is processed according to a user zoom factor request. As part of the fusion procedure, up-sampling may be applied on one or both of the grabbed images to scale it to the image grabbed by the Tele sub-camera or to a scale defined by the user. The fusion or up-sampling may be applied to only some of the pixels of a sensor. Down-

sampling can be performed as well if the output resolution is smaller than the sensor resolution.

The cameras and associated methods disclosed herein address and correct many of the problems and disadvantages of known dual-aperture optical zoom digital cameras. They provide an overall zoom solution that refers to all aspects: optics, algorithmic processing and system hardware (HW). The proposed solution distinguishes between video and still mode in the processing flow and specifies the optical requirements and HW requirements. In addition, it provides an innovative optical design that enables a low TTL/EFL ratio using a specific lens curvature order.

Due to the large focal length, objects that are in front or behind the plane of focus appear very blurry, and a nice foreground-to-background contrast is achieved. However, it is difficult to create such a blur using a compact camera with a relatively short focal length and small aperture size, such as a cell-phone camera. In some embodiments, a dual-aperture zoom system disclosed herein can be used to capture a shallow DOF photo (shallow compared with a DOF of a Wide camera alone), by taking advantage of the longer focal length of the Tele lens. The reduced DOF effect provided by the longer Tele focal length can be further enhanced in the final image by fusing data from an image captured simultaneously with the Wide lens. Depending on the distance to the object, with the Tele lens focused on a subject of the photo, the Wide lens can be focused to a closer distance than the subject so that objects behind the subject appear very blurry. Once the two images are captured, information from the out-of-focus blurred background in the Wide image is fused with the original Tele image background information, providing a blurrier background and even shallower DOF.

In an embodiment there is provided a zoom digital camera comprising a Wide imaging section that includes a fixed focal length Wide lens with a Wide FOV, a Wide sensor and a Wide image signal processor (ISP), the Wide imaging section operative to provide Wide image data of an object or scene; a Tele imaging section that includes a fixed focal length Tele lens with a Tele FOV that is narrower than the Wide FOV, a Tele sensor and a Tele ISP, the Tele imaging section operative to provide Tele image data of the object or scene; and a camera controller operatively coupled to the Wide and Tele imaging sections, the camera controller configured to combine in still mode at least some of the Wide and Tele image data to provide a fused output image of the object or scene from a particular point of view (POV), and to provide without fusion continuous zoom video mode output images of the object or scene, a camera controller operatively coupled to the Wide and Tele imaging sections, the camera controller configured to combine in still mode at least some of the Wide and Tele image data to provide a fused output image of the object or scene from a particular point of view and to provide without fusion continuous zoom video mode output images of the object or scene, each output image having a respective output resolution, wherein the video output images are provided with a smooth transition when switching between a lower zoom factor (ZF) value and a higher ZF value or vice versa, wherein at the lower ZF value the output resolution is determined by the Wide sensor, and wherein at the higher ZF value the output resolution is determined by the Tele sensor.

In an embodiment, the camera controller configuration to provide video output images with a smooth transition when switching between a lower ZF value and a higher ZF value or vice versa includes a configuration that uses at high ZF secondary information from the Wide camera and uses at

low ZF secondary information from the Tele camera. As used herein, "secondary information" refers to white balance gain, exposure time, analog gain and color correction matrix.

In a dual-aperture camera image plane, as seen by each sub-camera (and respective image sensor), a given object will be shifted and have different perspective (shape). This is referred to as point-of-view (POV). The system output image can have the shape and position of either sub-camera image or the shape or position of a combination thereof. If the output image retains the Wide image shape then it has the Wide perspective POV. If it retains the Wide camera position then it has the Wide position POV. The same applies for Tele images position and perspective. As used in this description, the perspective POV may be of the Wide or Tele sub-cameras, while the position POV may shift continuously between the Wide and Tele sub-cameras. In fused images, it is possible to register Tele image pixels to a matching pixel set within the Wide image pixels, in which case the output image will retain the Wide POV ("Wide fusion"). Alternatively, it is possible to register Wide image pixels to a matching pixel set within the Tele image pixels, in which case the output image will retain the Tele POV ("Tele fusion"). It is also possible to perform the registration after either sub-camera image is shifted, in which case the output image will retain the respective Wide or Tele perspective POV.

In an embodiment there is provided a method for obtaining zoom images of an object or scene in both still and video modes using a digital camera, the method comprising the steps of providing in the digital camera a Wide imaging section having a Wide lens with a Wide FOV, a Wide sensor and a Wide image signal processor (ISP), a Tele imaging section having a Tele lens with a Tele FOV that is narrower than the Wide FOV, a Tele sensor and a Tele ISP, and a camera controller operatively coupled to the Wide and Tele imaging sections; and configuring the camera controller to combine in still mode at least some of the Wide and Tele image data to provide a fused output image of the object or scene from a particular point of view, and to provide without fusion continuous zoom video mode output images of the object or scene, each output image having a respective output resolution, wherein the video mode output images are provided with a smooth transition when switching between a lower ZF value and a higher ZF value or vice versa, and wherein at the lower ZF value the output resolution is determined by the Wide sensor while at the higher ZF value the output resolution is determined by the Tele sensor.

BRIEF DESCRIPTION OF THE DRAWINGS

Non-limiting examples of embodiments disclosed herein are described below with reference to figures attached hereto that are listed following this paragraph. The drawings and descriptions are meant to illuminate and clarify embodiments disclosed herein, and should not be considered limiting in any way.

FIG. **1**A shows schematically a block diagram illustrating a dual-aperture zoom imaging system disclosed herein;

FIG. **1**B is a schematic mechanical diagram of the dual-aperture zoom imaging system of FIG. **1**A:

FIG. **2** shows an example of Wide sensor, Tele sensor and their respective FOVs;

FIG. **3** shows a schematically embodiment of CMOS sensor image grabbing vs. time;

FIG. **4** shows schematically a sensor time configuration which enables sharing one sensor interface using dual sensor zoom system;

FIG. **5** shows an embodiment of a method disclosed herein for acquiring a zoom image in capture mode;

FIG. **6** shows an embodiment of a method disclosed herein for acquiring a zoom image in video/preview mode;

FIG. **7** shows a graph illustrating an effective resolution zoom factor;

FIG. **8** shows one embodiment of a lens block in a thin camera disclosed herein;

FIG. **9** shows another embodiment of a lens block in a thin camera disclosed herein.

DETAILED DESCRIPTION

FIG. **1**A shows schematically a block diagram illustrating an embodiment of a dual-aperture zoom imaging system (also referred to as simply as "digital camera" or "camera") disclosed herein and numbered **100**. Camera **100** comprises a Wide imaging section ("sub-camera") that includes a Wide lens block **102**, a Wide image sensor **104** and a Wide image processor **106**. Camera **100** further comprises a Tele imaging section ("sub-camera") that includes a Tele lens block **108**, a Tele image sensor **110** and a Tele image processor **112**. The image sensors may be physically separate or may be part of a single larger image sensor. The Wide sensor pixel size can be equal to or different from the Tele sensor pixel size. Camera **100** further comprises a camera fusion processing core (also referred to as "controller") **114** that includes a sensor control module **116**, a user control module **118**, a video processing module **126** and a capture processing module **128**, all operationally coupled to sensor control block **110**. User control module **118** comprises an operational mode function **120**, a region of interest (ROI) function **122** and a zoom factor (ZF) function **124**.

Sensor control module **116** is connected to the two sub-cameras and to the user control module **118** and used to choose, according to the zoom factor, which of the sensors is operational and to control the exposure mechanism and the sensor readout. Mode choice function **120** is used for choosing capture/video modes. ROI function **122** is used to choose a region of interest. As used herein, "ROI" is a user defined as a sub-region of the image that may be exemplarily 4% or less of the image area. The ROI is the region on which both sub-cameras are focused on. Zoom factor function **124** is used to choose a zoom factor. Video processing module **126** is connected to mode choice function **120** and used for video processing. Still processing module **128** is connected to the mode choice function **120** and used for high image quality still mode images. The video processing module is applied when the user desires to shoot in video mode. The capture processing module is applied when the user wishes to shoot still pictures.

FIG. **1**B is a schematic mechanical diagram of the dual-aperture zoom imaging system of FIG. **1**A. Exemplary dimensions: Wide lens TTL=4.2 mm and EFL=3.5 mm; Tele lens TTL=6 mm and EFL=7 mm; both Wide and Tele sensors ⅓ inch. External dimensions of Wide and Tele cameras: width (w) and length (l)=8.5 mm and height (h)=6.8 mm. Distance "d" between camera centers=10 mm.

Following is a detailed description and examples of different methods of use of camera **100**.

Design for Continuous and Smooth Zoom in Video Mode

In an embodiment, in order to reach high quality continuous and smooth optical zooming in video camera mode

while reaching real optical zoom using fixed focal length sub-cameras, the system is designed according to the following rules (Equations 1-3):

$$\mathrm{Tan}(\mathrm{FOV}_{Wide})/\mathrm{Tan}(\mathrm{FOV}_{Tele})=PL_{Wide}/PL_{video} \quad (1)$$

where Tan refers to "tangent", while FOV_{Wide} and FOV_{Tele} refer respectively to the Wide and Tele lens fields of view (in degrees). As used herein, the FOV is measured from the center axis to the corner of the sensor (i.e. half the angle of the normal definition). PL_{Wide} and PL_{video} refer respectively to the "in-line" (i.e. in a line) number of Wide sensor pixels and in-line number of output video format pixels. The ratio $\mathrm{PL}_{Wide}/\mathrm{PL}_{video}$ is called an "oversampling ratio". For example, in order to get full and continuous optical zoom experience with a 12 Mp sensor (sensor dimensions 4000×3000) and a required 1080 p (dimension 1920×1080) video format, the FOV ratio should be 4000/1920=2.083. Moreover, if the Wide lens FOV is given as $\mathrm{FOV}_{Wide}=37.5^{0}$, the required Tele lens FOV is 20.2^{0} The zoom switching point is set according to the ratio between sensor pixels in-line and the number of pixels in-line in the video format and defined as:

$$Z_{switch}=PL_{Wide}/PL_{video} \quad (2)$$

Maximum optical zoom is reached according to the following formula:

$$Z_{max}=\mathrm{Tan}(\mathrm{FOV}_{Wide})/\mathrm{Tan}(\mathrm{FOV}_{Tele})*PL_{Tele}/PL_{video} \quad (3)$$

For example: for the configuration defined above and assuming $\mathrm{PL}_{Tele}=4000$ and $\mathrm{PL}_{video}=1920$, $Z_{max}=4.35$.

In an embodiment, the sensor control module has a setting that depends on the Wide and Tele FOVs and on a sensor oversampling ratio, the setting used in the configuration of each sensor. For example, when using a 4000×3000 sensor and when outputting a 1920×1080 image, the oversampling ratio is 4000/1920=2.0833.

In an embodiment, the Wide and Tele FOVs and the oversampling ratio satisfy the condition

$$0.8*PL_{Wide}/PL_{video}<\mathrm{Tan}(\mathrm{FOV}_{Wide})/\mathrm{Tan}(\mathrm{FOV}_{Tele})<1.2*PL_{Wide}/PL_{video}. \quad (4)$$

Still Mode Operation/Function

In still camera mode, the obtained image is fused from information obtained by both sub-cameras at all zoom levels, see FIG. **2**, which shows a Wide sensor **202** and a Tele sensor **204** and their respective FOVs. Exemplarily, as shown, the Tele sensor FOV is half the Wide sensor FOV. The still camera mode processing includes two stages: (1) setting HW settings and configuration, where a first objective is to control the sensors in such a way that matching FOVs in both images (Tele and Wide) are scanned at the same time. A second objective is to control the relative exposures according to the lens properties. A third objective is to minimize the required bandwidth from both sensors for the ISPs; and (2) image processing that fuses the Wide and the Tele images to achieve optical zoom, improves SNR and provides wide dynamic range.

FIG. **3** shows image line numbers vs. time for an image section captured by CMOS sensors. A fused image is obtained by line (row) scans of each image. To prevent matching FOVs in both sensors to be scanned at different times, a particular configuration is applied by the camera controller on both image sensors while keeping the same frame rate. The difference in FOV between the sensors determines the relationship between the rolling shutter time and the vertical blanking time for each sensor. In the particular configuration, the scanning is synchronized such that the same points of the object in each view are obtained simultaneously.

Specifically with reference to FIG. **3** and according to an embodiment of a method disclosed herein, the configuration to synchronize the scanning includes: setting the Tele sensor vertical blanking time VB_{Tele} to equal the Wide sensor vertical blanking time VB_{Wide} plus half the Wide sensor rolling shutter time RST_{Wide}; setting the Tele and Wide sensor exposure times ET_{Tele} and ET_{Wide} to be equal or different; setting the Tele sensor rolling shutter time RST_{Tele} to be $0.5*\mathrm{RST}_{Wide}$; and setting the frame rates of the two sensors to be equal. This procedure results in identical image pixels in the Tele and Wide sensor images being exposed at the same time

In another embodiment, the camera controller synchronizes the Wide and Tele sensors so that for both sensors the rolling shutter starts at the same time.

The exposure times applied to the two sensors could be different, for example in order to reach same image intensity using different F# and different pixel size for the Tele and Wide systems. In this case, the relative exposure time may be configured according to the formula below:

$$\mathrm{ET}_{Tele}=\mathrm{ET}_{Wide}\cdot(F\#_{Tele}/F\#_{Wide})^2\cdot(\text{Pixel size}_{Wide}/\text{Pixel size}_{Tele})^2 \quad (5)$$

Other exposure time ratios may be applied to achieve wide dynamic range and improved SNR. Fusing two images with different intensities will result in wide dynamic range image.

In more detail with reference to FIG. **3**, in the first stage, after the user chooses a required zoom factor ZF, the sensor control module configures each sensor as follows:

1) Cropping index Wide sensor:

$$Y_{Wide\ start}=1/2\cdot PC_{Wide}(1-1/\mathrm{ZF})$$

$$Y_{Wide\ end}=1/2\cdot PC_{Wide}(1+1/\mathrm{ZF})$$

where PC is the number of pixels in a column, and Y is the row number

2) Cropping index Tele sensor:

If ZF>Tan (FOV_{Wide})/Tan (FOV_{Tele}), then

$$Y_{Tele\ start}=1/2\cdot PC_{Tele}(1-(1/\mathrm{ZF})\cdot\mathrm{Tan}(\mathrm{FOV}_{Tele})/\mathrm{Tan}(\mathrm{FOV}_{Wide}))$$

$$Y_{Tele\ end}=1/2\cdot PC_{Tele}(1+(1/\mathrm{ZF})\cdot\mathrm{Tan}(\mathrm{FOV}_{Tele})/\mathrm{Tan}(\mathrm{FOV}_{Wide}))$$

If ZF<Tan (FOV_{Wide})/Tan (FOV_{Tele}), then

$$Y_{Tele\ start}=0$$

$$Y_{Tele\ end}=PC_{Tele}$$

This will result in an exposure start time of the Tele sensor with a delay of (in numbers of lines, relative to the Wide sensor start time):

$$(1-\mathrm{ZF}/((\mathrm{Tan}(\mathrm{FOV}_{Wide})/\mathrm{Tan}(\mathrm{FOV}_{Tele}))))\cdot 1/(2\cdot\mathrm{FPS}) \quad (6)$$

where FPS is the sensor's frame per second configuration. In cases where ZF>Tan (FOV_{Wide})/Tan (FOV_{Tele}), no delay will be introduced between Tele and Wide exposure starting point. For example, for a case where Tan (FOV_{Wide})/Tan (FOV_{Tele})=2 and ZF=1, the Tele image first pixel is exposed 1/4·(1/FPS) second after the Wide image first pixel was exposed.

After applying the cropping according to the required zoom factor, the sensor rolling shutter time and the vertical blank should be configured in order to satisfy the equation to keep the same frame rate:

$$\mathrm{VB}_{Wide}+\mathrm{RST}_{Wide}=\mathrm{VB}_{Tele}+\mathrm{RST}_{Tele} \quad (7)$$

FIG. **3** exemplifies Eq. (7), One way to satisfy Eq. (7) is to increase the RST_{Wide}. Controlling the RST_{Wide} may be done by changing the horizontal blanking (HB) of the Wide sensor. This will cause a delay between the data coming out from each row of the Wide sensor.

Generally, working with a dual-sensor system requires multiplying the bandwidth to the following block, for example the ISP. For example, using 12 Mp working at 30 fps, 10 bit per pixel requires working at 3.6 Gbit/sec. In this example, supporting this bandwidth requires 4 lanes from each sensor to the respective following ISP in the processing chain. Therefore, working with two sensors requires double bandwidth (7.2 Gbit/sec) and 8 lanes connected to the respective following blocks. The bandwidth can be reduced by configuring and synchronizing the two sensors. Consequently, the number of lanes can be half that of a conventional configuration (3.6 Gbit/sec).

FIG. **4** shows schematically a sensor time configuration that enables sharing one sensor interface using a dual-sensor zoom system, while fulfilling the conditions in the description of FIG. **3** above. For simplicity, assuming the Tele sensor image is magnified by a factor of 2 compared with the Wide sensor image, the Wide sensor horizontal blanking time HB_{Wide} is set to twice the Wide sensor line readout time. This causes a delay between output Wide lines. This delay time matches exactly the time needed to output two lines from the Tele sensor. After outputting two lines from the Tele sensor, the Tele sensor horizontal blanking time HB_{Tele} is set to be one Wide line readout time, so, while the Wide sensor outputs a row from the sensor, no data is being output from the Tele sensor. For this example, every 3^{rd} line in the Tele sensor is delayed by an additional HB_{Tele}. In this delay time, one line from the Wide sensor is output from the dual-sensor system. After the sensor configuration stage, the data is sent in parallel or by using multiplexing into the processing section.

FIG. **5** shows an embodiment of a method disclosed herein for acquiring a zoom image in still mode. In ISP step **502**, the data of each sensor is transferred to the respective ISP component, which performs on the data various processes such as denoising, demosaicing, sharpening, scaling, etc, as known in the art. After the processing in step **502**, all following actions are performed in capture processing core **128**: in rectification step **504**, both Wide and Tele images are aligned to be on the epipolar line; in registration step **506**, mapping between the Wide and the Tele aligned images is performed to produce a registration map; in resampling step **508**, the Tele image is resampled according to the registration map, resulting in a re-sampled Tele image; in decision step **510**, the re-sampled Tele image and the Wide image are processed to detect errors in the registration and to provide a decision output. In more detail, in step **510**, the re-sampled Tele image data is compared with the Wide image data and if the comparison detects significant dissimilarities, an error is indicated. In this case, the Wide pixel values are chosen to be used in the output image. Then, in fusion step **512**, the decision output, re-sampled Tele image and the Wide image are fused into a single zoom image.

To reduce processing time and power, steps **506**, **508**, **510**, **512** could be bypassed by not fusing the images in non-focused areas. In this case, all steps specified above should be applied on focused areas only. Since the Tele optical system will introduce shallower depth of field than the Wide optical system, defocused areas will suffer from lower contrast in the Tele system.

Zoom-in and Zoom-Out in Still Camera Mode

We define the following: TFOV=tan (camera FOV/2). "Low ZF" refers to all ZF that comply with ZF<Wide TFOV/Tele TFOV. "High ZF" refers to all ZF that comply with ZF>Wide TFOV/Tele TFOV. "ZFT" refers to a ZF that complies with ZF=Wide TFOV/Tele TFOV. In one embodiment, zoom-in and zoom-out in still mode is performed as follows:

Zoom-in: at low ZF up to slightly above ZFT, the output image is a digitally zoomed, Wide fusion output. For the up-transfer ZF, the Tele image is shifted and corrected by global registration (GR) to achieve smooth transition. Then, the output is transformed to a Tele fusion output. For higher (than the up-transfer) ZF, the output is the Tele fusion output digitally zoomed.

Zoom-out: at high ZF down to slightly below ZFT, the output image is a digitally zoomed, Tele fusion output. For the down-transfer ZF, the Wide image is shifted and corrected by GR to achieve smooth transition. Then, the output is transformed to a Wide fusion output. For lower (than the down-transfer) ZF, the output is basically the down-transfer ZF output digitally zoomed but with gradually smaller Wide shift correction, until for ZF=1 the output is the unchanged Wide camera output.

In another embodiment, zoom-in and zoom-out in still mode is performed as follows:

Zoom-in: at low ZF up to slightly above ZFT, the output image is a digitally zoomed, Wide fusion output. For the up-transfer ZF and above, the output image is the Tele fusion output.

Zoom-out: at high ZF down to slightly below ZFT, the output image is a digitally zoomed, Tele fusion output. For the down-transfer ZF and below, the output image is the Wide fusion output.

Video Mode Operation/Function

Smooth Transition

When a dual-aperture camera switches the camera output between sub-cameras or points of view, a user will normally see a "jump" (discontinuous) image change. However, a change in the zoom factor for the same camera and POV is viewed as a continuous change. A "smooth transition" is a transition between cameras or POVs that minimizes the jump effect. This may include matching the position, scale, brightness and color of the output image before and after the transition. However, an entire image position matching between the sub-camera outputs is in many cases impossible, because parallax causes the position shift to be dependent on the object distance. Therefore, in a smooth transition as disclosed herein, the position matching is achieved only in the ROI region while scale brightness and color are matched for the entire output image area.

Zoom-In and Zoom-Out In Video Mode

In video mode, sensor oversampling is used to enable continuous and smooth zoom experience. Processing is applied to eliminate the changes in the image during cross-over from one sub-camera to the other. Zoom from 1 to Z_{switch} is performed using the Wide sensor only. From Z_{switch} and on, it is performed mainly by the Tele sensor. To prevent "jumps" (roughness in the image), switching to the Tele image is done using a zoom factor which is a bit higher ($Z_{switch}+\Delta Zoom$) than Z_{switch}. ΔZoom is determined according to the system's properties and is different for cases where zoom-in is applied and cases where zoom-out is applied ($\Delta Zoom_{in} \neq \Delta Zoom_{out}$). This is done to prevent residual jumps artifacts to be visible at a certain zoom factor. The switching between sensors, for an increasing zoom and for decreasing zoom, is done on a different zoom factor.

The zoom video mode operation includes two stages: (1) sensor control and configuration, and (2) image processing. In the range from 1 to Z_{switch}, only the Wide sensor is operational, hence, power can be supplied only to this sensor. Similar conditions hold for a Wide AF mechanism. From Z_{switch}+ΔZoom to Z_{max} only the Tele sensor is operational, hence, power is supplied only to this sensor. Similarly, only the Tele sensor is operational and power is supplied only to it for a Tele AF mechanism. Another option is that the Tele sensor is operational and the Wide sensor is working in low frame rate. From Z_{switch} to Z_{switch}+ΔZoom, both sensors are operational.

Zoom-in: at low ZF up to slightly above ZFT, the output image is the digitally zoomed, unchanged Wide camera output. For the up-transfer ZF, the output is a transformed Tele sub-camera output, where the transformation is performed by a global registration (GR) algorithm to achieve smooth transition. For higher (than the up-transfer), the output is the transfer ZF output digitally zoomed.

Zoom-out: at high ZF down to slightly below ZFT, the output image is the digitally zoomed transformed Tele camera output. For the down-transfer ZF, the output is a shifted Wide camera output, where the Wide shift correction is performed by the GR algorithm to achieve smooth transition, i.e. with no jump in the ROI region. For lower (than the down-transfer) ZF, the output is basically the down-transfer ZF output digitally zoomed but with gradually smaller Wide shift correction, until for ZF=1 the output is the unchanged Wide camera output.

FIG. **6** shows an embodiment of a method disclosed herein for acquiring a zoom image in video/preview mode for 3 different zoom factor (ZF) ranges: (a) ZF range=1: Z_{switch}; (b) ZF range=Z_{switch}:Z_{switch}+$\Delta Zoom_{in}$: and (c) Zoom factor range=Z_{switch}+$\Delta Zoom_{in}$:Z_{max}. The description is with reference to a graph of effective resolution vs. zoom value (FIG. **7**). In step **602**, sensor control module **116** chooses (directs) the sensor (Wide, Tele or both) to be operational. Specifically, if the ZF range=1:Z_{switch}, module **116** directs the Wide sensor to be operational and the Tele sensor to be non-operational. If the ZF range is Z_{switch}: Z_{switch}+$\Delta Zoom_{in}$, module **116** directs both sensors to be operational and the zoom image is generated from the Wide sensor. If the ZF range is Z_{switch}+$\Delta Zoom_{in}$:Z_{max}, module **116** directs the Wide sensor to be non-operational and the Tele sensor to be operational. After the sensor choice in step **602**, all following actions are performed in video processing core **126**. Optionally, in step **604**, color balance is calculated if two images are provided by the two sensors. Optionally yet, in step **606**, the calculated color balance is applied in one of the images (depending on the zoom factor). Further optionally, in step **608**, registration is performed between the Wide and Tele images to output a transformation coefficient. The transformation coefficient can be used to set an AF position in step **610**. In step **612**, an output of any of steps **602-608** is applied on one of the images (depending on the zoom factor) for image signal processing that may include denoising, demosaicing, sharpening, scaling, etc. In step **614**, the processed image is resampled according to the transformation coefficient, the requested ZF (obtained from zoom function **124**) and the output video resolution (for example 1080 p). To avoid a transition point to be executed at the same ZF, ΔZoom can change while zooming in and while zooming out. This will result in hysteresis in the sensor switching point.

In more detail, for ZF range 1:Z_{switch}, for ZF<Z_{switch}, the Wide image data is transferred to the ISP in step **612** and resampled in step **614**. For ZF range=Z_{switch}:Z_{switch}+$\Delta Zoom_{in}$, both sensors are operational and the zoom image is generated from the Wide sensor. The color balance is calculated for both images according to a given ROI. In addition, for a given ROI, registration is performed between the Wide and Tele images to output a transformation coefficient. The transformation coefficient is used to set an AF position. The transformation coefficient includes the translation between matching points in the two images. This translation can be measured in a number of pixels. Different translations will result in a different number of pixel movements between matching points in the images. This movement can be translated into depth and the depth can be translated into an AF position. This enables to set the AF position by only analyzing two images (Wide & Tele). The result is fast focusing.

Both color balance ratios and transformation coefficient are used in the ISP step. In parallel, the Wide image is processed to provide a processed image, followed by resampling. For ZF range=Z_{switch}+$\Delta Zoom_{in}$:Z_{max} and for Zoom factor>Z_{switch}, +$\Delta Zoom_{in}$, the color balance calculated previously is now applied on the Tele image. The Tele image data is transferred to the ISP in step **612** and resampled in step **614**. To eliminate crossover artifacts and to enable smooth transition to the Tele image, the processed Tele image is resampled according to the transformation coefficient, the requested ZF (obtained from zoom function **124**) and the output video resolution (for example 1080 p).

FIG. **7** shows the effective resolution as a function of the zoom factor for a zoom-in case and for a a zoom-out case $\Delta Zoom_{up}$ is set when we zoom in, and $\Delta Zoom_{down}$ is set when we zoom out. Setting $\Delta Zoom_{up}$ to be different from $\Delta Zoom_{down}$ will result in transition between the sensors to be performed at different zoom factor ("hysteresis") when zoom-in is used and when zoom-out is used. This hysteresis phenomenon in the video mode results in smooth continuous zoom experience.

Optical Design

Additional optical design considerations were taken into account to enable reaching optical zoom resolution using small total track length (TTL). These considerations refer to the Tele lens. In an embodiment, the camera is "thin" (see also FIG. **1**B) in the sense that is has an optical path of less than 9 mm and a thickness/focal length (FP) ratio smaller than about 0.85. Exemplarily, as shown in FIG. **8**, such a thin camera has a lens block that includes (along an optical axis starting from an object) five lenses: a first lens element **802** with positive power and two lenses **804** and **806** and with negative power, a fourth lens **808** with positive power and a fifth lens **810** with negative power. In the embodiment of FIG. **8**, the EFL is 7 mm, the TTL is 4.7 mm, f=6.12 and FOV=20^{0}. Thus the Tele lens TTL/EFL ratio is smaller than 0.9. In other embodiments, the Tele lens TTL/EFL ratio may be smaller than 1.

In another embodiment of a lens block in a thin camera, shown in FIG. **9**, the camera has a lens block that includes (along an optical axis starting from an object) a first lens element **902** with positive power a second lens element **904** with negative power, a third lens element with positive power **906** and a fourth lens element with negative power **908**, and a fifth lens element **910** with positive or negative power. In this embodiment, f=7.14, F#=3.5, TTL=5.8 mm and FOV=22.7^{0}.

In conclusion, dual aperture optical zoom digital cameras and associate methods disclosed herein reduce the amount of processing resources, lower frame rate requirements, reduce power consumption, remove parallax artifacts and provide continuous focus (or provide loss of focus) when changing

from Wide to Tele in video mode. They provide a dramatic reduction of the disparity range and avoid false registration in capture mode. They reduce image intensity differences and enable work with a single sensor bandwidth instead of two, as in known cameras.

All patent applications mentioned in this specification are herein incorporated in their entirety by reference into the specification, to the same extent as if each individual patent application was specifically and individually indicated to be incorporated herein by reference. In addition, citation or identification of any reference in this application shall not be construed as an admission that such reference is available as prior art to the present disclosure.

While this disclosure has been described in terms of certain embodiments and generally associated methods, alterations and permutations of the embodiments and methods will be apparent to those skilled in the art. The disclosure is to be understood as not limited by the specific embodiments described herein, but only by the scope of the appended claims.

What is claimed is:

1. A zoom digital camera comprising:

a) a first imaging section that includes a fixed focal length first lens with a first field of view (FOV_1) and a first image sensor, the first imaging section operative to provide first image data of an object or scene;

b) a second imaging section that includes a fixed focal length second lens with a second FOV (FOV_2) that is narrower than FOV_1 and a second image sensor, the second imaging section operative to provide second image data of the object or scene; and

c) a camera controller operatively coupled to the first and second imaging sections, the camera controller configured to provide an output image having a focused subject, wherein the output image exhibits a shallow depth of focus (DOF) effect in which objects in front of or behind the focused subject appear blurry, wherein the focused subject is provided by the second lens and wherein the objects behind the focused subject appear blurry due to the first lens being focused to a closer distance than the subject.

2. The zoom digital camera of claim **1**, wherein the output image is a still mode output image.

3. The zoom digital camera of claim **1**, wherein, for a portrait photo, the output image exhibiting a shallow DOF effect is similar to a portrait photo taken with a digital single-lens reflex (DSLR) camera.

4. The zoom digital camera of claim **3**, wherein the DSLR has a focal length between 50-80 mm.

5. A zoom digital camera comprising:

a) a first imaging section that includes a fixed focal length first lens with a first field of view (FOV_1) and a first image sensor; and

b) a second imaging section that includes a fixed focal length second lens with a second FOV (FOV2) that is narrower than FOV, and a second image sensor, wherein the second lens includes five lens elements along an optical axis starting from an object starting with a first lens element with positive power, wherein the five lens elements further include a second lens element with negative power, a fourth lens element with negative power and a fifth lens element, wherein a largest distance between consecutive lens elements along the optical axis is a distance between the fourth lens element and the fifth lens element, and wherein a ratio of a total track length (TTL) to effective focal length (EFL) of the second lens is smaller than 1.

6. The zoom digital camera of claim **5**, further comprising a camera controller operatively coupled to the first and second imaging sections, the camera controller configured to provide video output images with a smooth transition when switching between a lower zoom factor (ZF) value and a higher ZF value or vice versa.

7. A zoom digital camera comprising:

a) a first imaging section that includes a fixed focal length first lens with a first field of view (FOV_1) and a first image sensor, the first imaging section operative to provide first image data of an object or scene;

b) a second imaging section that includes a fixed focal length second lens with a second FOV (FOV_2) that is narrower than FOV_1 and a second image sensor, the second imaging section operative to provide second image data of the object or scene; and

c) a camera controller operatively coupled to the first and second imaging sections, the camera controller configured to provide an output image having a focused subject, wherein the output image exhibits a shallow depth of focus (DOF) effect in which objects in front of or behind the focused subject appear blurry, wherein the shallow DOF effect is achieved by focusing the first lens on a distance closer than the subject to thereby obtain the first image data comprising out-of-focus blurred background image data, and focusing the second lens on the subject to obtain the second image data; and fusing the first image data with the second image data to increase blurriness of background of the output image.

* * * * *